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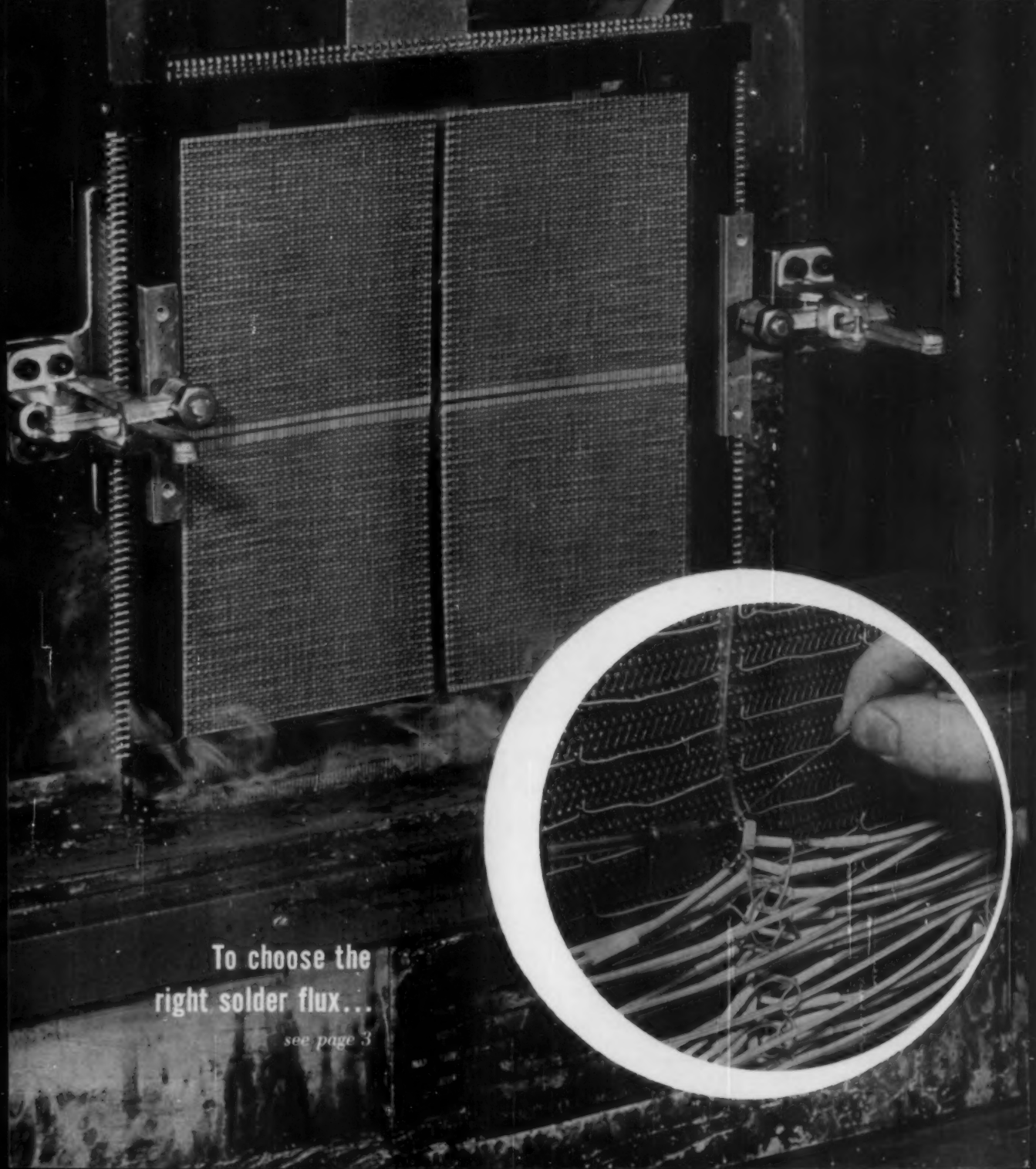
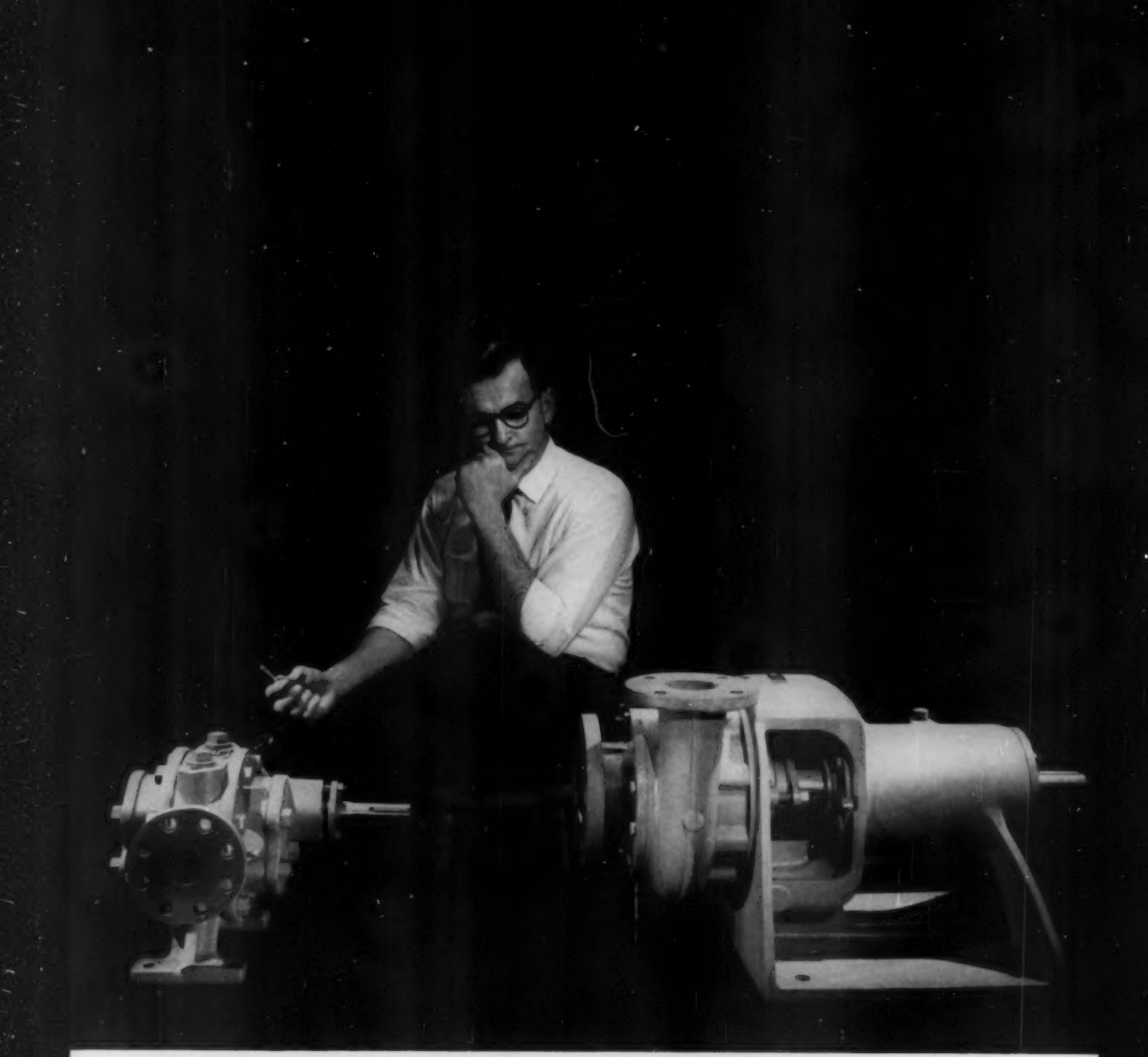
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT • JUNE 13, 1960



To choose the right solder flux...

see page 3



ROTARY OR CENTRIFUGAL

...Which one is best for your application?

Rotary or centrifugal? Sometimes the choice is easy. For example, you would use a rotary pump for very viscous liquids (over 2500 s.s.u.). Or where poor suction conditions exist. Or when positive displacement is required. Centrifugal pumps would be used for extremely corrosive or abrasive liquids, low viscosity liquids (under 2500 s.s.u.) water, slurries, or petroleum products.

But . . . in many applications combinations of these factors exist. Or the liquid you want to pump is not clearly in either area. Then there are other considerations such as initial cost, operating cost, lubrication value of the liquid, location and even budget limitations.

All of these considerations can put you in the middle—where either a rotary or centrifugal can be used. The best choice can only be made by someone with experience and knowledge of both types.

As one of the few manufacturers of a complete line of both rotary and centrifugal pumps, Worthington can help you select the best, most economical solution to this perennial pump problem. For the name and address of your nearest Worthington representative, consult the yellow pages.

P.S. If you'd like a copy of a 50-page booklet, "Rotary and Centrifugal Pumps: Theory and Design," please write to Worthington Corporation, Section 20-14, Harrison, New Jersey, for bulletin G-2666.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

June 13, 1960 Vol. 31, No. 24

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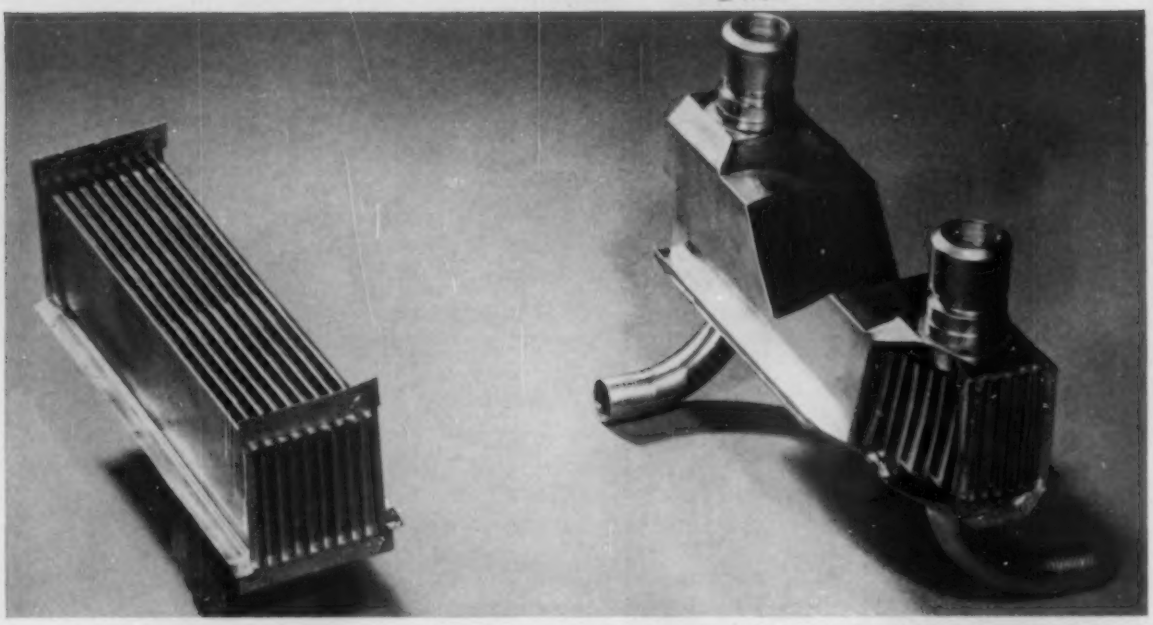
Heat exchanger of Armco Stainless saves money, helps save lives



Blood and water are separated by the strong walls of the core (left) made from .005-inch Armco Stainless Steel. At right is a cut-away showing core in place in the case of Armco Stainless.

This tiny stainless heat exchanger made by the Surgical Instrument Company (Joseph A. Chyba and Sons), Baltimore, Maryland, protects human lives. During open-heart surgery, it cools the patient's blood to a point that surgeons consider safer. Even though it's used only once, it saves money compared with permanent types.

High tensile strength of Armco 18-8 Stainless Steel permits use of .005-inch thick core walls. These thin-gage stainless walls make the unit more efficient. In addition, Armco Stainless for case and tubes results in a unit that can be guaranteed sterile and pyrogen-free, and won't corrode in storage.

LOW IN COST

This unit costs less than a half-pint of blood, about $\frac{1}{20}$th as much as the cheapest of non-disposable units. It weighs only 7 ounces, compared to about 25 pounds for a permanent type. Moreover, the larger units take about a pint of blood to prime them and require thorough cleaning after use. This disposable unit can be used once, then thrown away at a saving for blood alone.

As in this unique heat exchanger, Armco Stainless Steels—sheets, strip, bars and wire—in more than 60 analyses and a broad range of gages, sizes, finishes and conditions, offer specific opportunities for savings and improved performance in thousands of products. Perhaps yours is one of them. Just mail the coupon for complete information.

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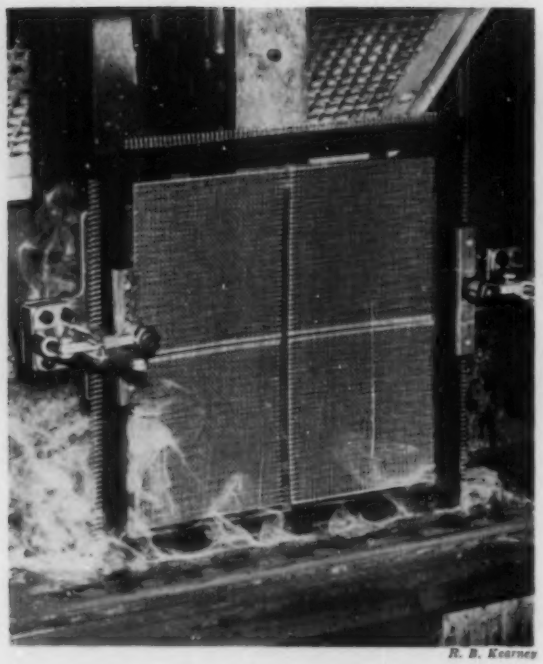
INTERESTING TO NOTE

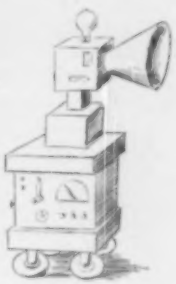


R. B. Kearney

On our cover–a core plane for IBM's 7302 Core Storage Unit is undergoing automatic dip-soldering. Note the flux fumes being removed from the assembly by ventilation. There are more than 100,000 soldered connections.

Additional wire leads to the core-plane array terminals are soldered by hand, as shown in the cover insert. Although the automatic dip method is 128 times faster than hand soldering, there are still joints inaccessible to machine.

H. H. Manko, author of the article, "How to Choose the Right Solder Flux," (p 43) tells us that no matter how complicated the soldering machine or how experienced the manual solderer, there is still no way to check the effectiveness of the soldered joint without destroying it. Since a nondestructive solder tester is an area open for the inventive mind, Manko has contributed this sketch of a proposed "solder sniffer." Manko leaves the interior design up to you.



P & W's 100th Birthday

Within a half century after Eli Whitney began turning out muskets with interchangeable parts, the United States was involved in a Civil War (called the first "modern war" by historian Bruce Catton, because guns were available that could shoot accurately more than 100 yards). At the war's outset, however, even though some weapons had interchangeable parts, most of the guns were of different types, and used many different sizes of shot, so that few divisions had weapons in common. What was needed was a large company to manufacture the

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machine tools necessary for mass-producing standardized weapons.

Such was the beginning of Pratt & Whitney Co Inc, which celebrated its 100th anniversary last month. Its founders, Francis A. Pratt and Amos Whitney, had somewhat parallel careers before joining forces. Pratt was born in New York, but grew up in Lowell, Mass. After grammar school, he became a mechanic's apprentice. At 25, he moved on to Colt's "pistol factory"—practically a graduate school for the finest mechanics the country was developing. From Colt he moved on to become superintendent at Phoenix Iron Works (now Taylor & Fenn Co). The younger partner, Amos Whitney, was born in Biddeford, Me, and was a member of another branch of the family that produced Eli Whitney. At 14, Amos was apprenticed to the Essex Machine Co in Lawrence, Mass, and later followed his father, an expert machinist and locksmith, to Colt. Then he, too, moved on to Phoenix Iron Works, and there met Francis Pratt.

Francis Pratt

Their company was born in a small rented room in Hartford, where Pratt and Whitney worked in their spare time with the few tools they owned. The only furniture in the room was a stove. They had not yet given up full-time jobs at Phoenix, but there was plenty of work for skilled mechanics, both job work and creative designing, and the partners were busy.

The shop had just begun to be recognized as a going concern when fire burned out the room and destroyed all the equipment. However, in less than a year they were in business again. Within a few years, the company was heavily involved in the manufacture of firearms, and it was this work that gave impetus to mass-producing interchangeable parts. Although Whitney and Colt had made a start with their weapons made with interchangeable parts, it wasn't carried to other fields. In their days, every piece of machinery was assembled and fitted by hand, and no two parts supposedly the same would interchange. Large-volume work of such precise nature as the Civil War firearms project had never been attempted before, and the idea was scoffed at by seasoned mechanics. But Pratt and Whitney made the idea practical on a large scale. Much of their success was due to their awareness of the need for development and use of accurate gages and trustworthy standards of length.

Amos Whitney

There was no commercial standard inch at that time, and there were almost as many commercial "standard" yards as there were yardsticks. Pratt & Whitney soon realized that an exact standard inch was the basic requirement for interchangeability. Many years of refining the gaging tools already in existence, and inventing new tools, gradually led, in 1882, to the Rogers-Bond Comparator. In 1879, backed by the resources at Pratt & Whitney, William A. Rogers, then a professor of astronomy at Harvard College, and George M. Bond of Stevens Institute of Technology, set up a research and development program that led, three years later, to this comparator, a device that made accurate measurements within 1/50,000 in. For a discussion of standards that can be applied to today's machine tools and many other products, see the article on page 51. —Benedict A Leerburger, Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **What's Available in Digital Storage Devices**
How the new devices perform and where each type works best.

. . . **Forming Beryllium Sheet**
The precautions you should take before drawing this soft but brittle metal.

. . . **Three-dimensional Drives**
Seven popular types of drives which transmit motion between nonparallel shafts.

. . . **You and Your Employer**
Special report examines: what engineers want in nonfinancial requirements; what fringe benefits employers offer; and signing that patent agreement.

. . . **Common Area of Intersecting Circles**
A fast method that will give quick, preliminary estimates.

. . . **Points of View**
He's an engineer, architect, designer—R. Buckminster Fuller discusses patents, education and industrial designers.

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ONE pump becomes MANY . . . saving you pump dollars . . . giving you a wide range of clear water, non-clog and other liquid-handling modifications . . . when you standardize your pumping operations with Fairbanks, Morse ADAPT-*ABLE* pumps.

F-M ADAPT-*ABLES* consist of a pump frame and simple adapter to which can be attached a wide variety of F-M hydraulic ends with enclosed, semi-open or non-clog impellers. Conversion is easy . . . inexpensive, too.

F-M ADAPT-*ABLES* are "*NEMA-Matched*": pump mounting dimensions are standardized with similar dimensions of Nema-driving motors. Gone is the need for make-shift height-adjusting blocks and odd-bore couplings!

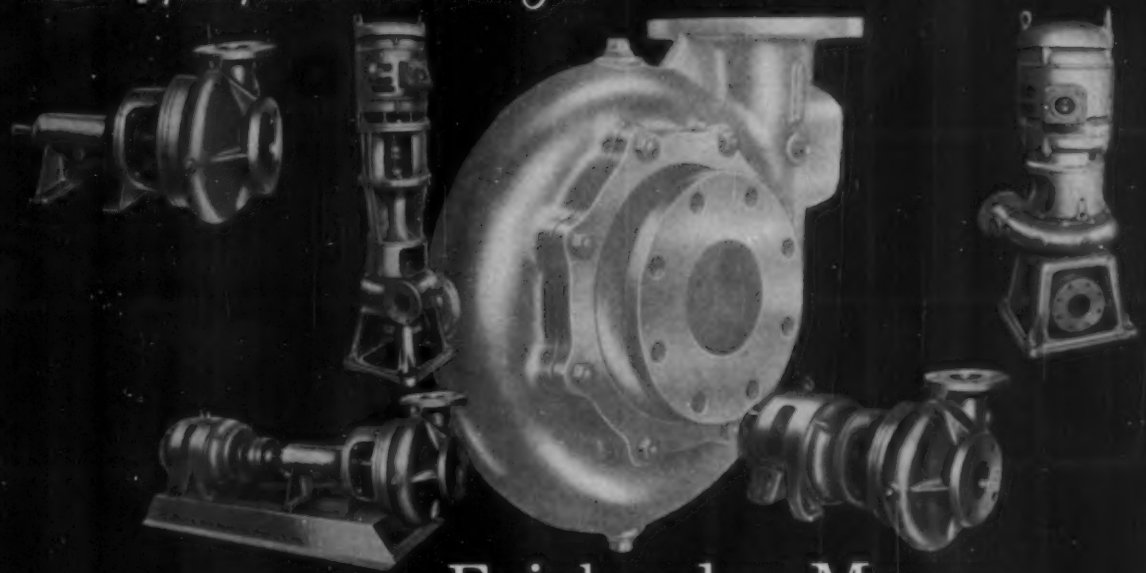
The ADAPT-*ABLE* design means that the most economical frame size may be selected to match the motor horsepower requirements of the pumping job.

And there are other advantages: choice of mechanical seals or conventional stuffing boxes with easy field change-over from one to the other . . . interchangeable bearings for pumps and motors. For special liquid handling problems, hydraulic ends can be specially alloyed to fit the needs: we've been solving such problems for generations.

Regardless of *what* liquids you pump . . . or *where* . . . Fairbanks, Morse builds pumps and *matching* power units for *your* use . . . in a greater range of sizes, types and capacities than *anyone, anywhere*. Start SAVING pump and motor dollars by putting F-M's vast hydraulic experience to work in your plants, process lines and products . . . now!

"nema-matched" *adapt-ables*

. . . a lot of pumps in ONE package!



Fairbanks, Morse

THE PROUDEST NAME IN PUMPS

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DEVELOPMENTS TO WATCH...

Midget valve controls either pneumatic or hydraulic circuit

Electro-hydraulic valves smaller than any previously available are now being readied for production at Electric Autolite. These screw-in units will operate on hydraulic or pneumatic systems, can be used as pilots in large-valve circuits, or as a direct-control devices in small-flow circuits.

Autolite now has two series available for evaluation. One is a 0.2 amp, 12 v dc unit, 0.352 in. dia and 1.350 in. long that will handle a flow of approximately 50 cu in./min. with a 100-psi pressure drop. The other is a 1 amp, 12 v dc unit, 0.687 in. dia with an over-all length of 1.898 in., and will handle a 327 cu in./min. flow.

New additive and finishing system improve copper parts

An alloying addition that gives copper unusual resistance to bio-fouling, dezincification, and other forms of copper attack; and a new pretreatment system that's claimed to produce an usually clean, receptive surface for electroplating, are among the new developments that promise improved copper parts.

The alloying addition is mercury. Bridgeport Brass is using it in its new Alloy 77 heat exchanger tubing, and says this represents the first commercial use of this metal in a copper-base alloy. The alloy itself meets standard ASTM specifications for heat exchanger tubing, is priced in the range between Admiralty and aluminum brass.

The new pretreatment, announced by Becco Chemical Div, Food Machinery & Chemical Corp., is a brief dip in a 25% ammonium persulfate solution, followed by a warm water rinse. It replaces the conventional acid pickle; and, says Becco, reduces pinholing of nickel plate as much as 73%, of gold plate as much as 85%. The treatment can be applied with standard equipment, and chemical cost is "only a few tenths of a cent per sq ft."

Glass research promises super fibers

Glass fibers that stand temperatures above 4500 F, and have "far higher tensile strengths and much larger moduli of elasticity" than ordinary glass fibers, are being developed at U of Pittsburgh.

These are not ordinary glasses, of course. They have lower silica contents—generally under 50%—and increased amounts of alumina, zirconia, and magnesia.

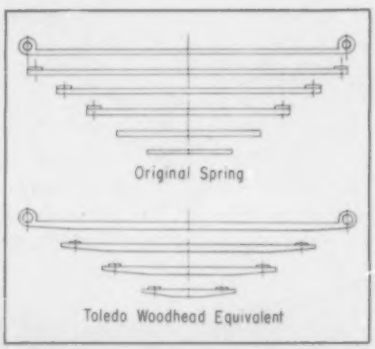
The 4500-F figure has not been reached yet. But Prof Alexander Silverman says a big step forward has been made, and he has every expectation that this goal—and perhaps even 4800 F—will be a reality before the current project is completed.

Another angle on spring design

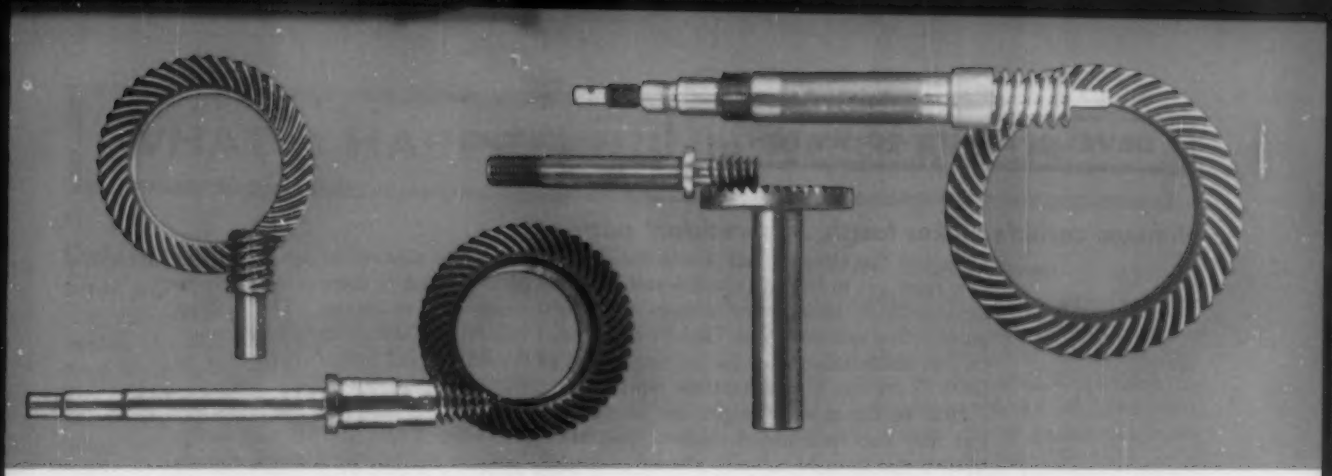
A "rational leaf" design that "approaches the ideal of uniform stress far more closely than any previous configuration," with correspondingly large savings in material and cost, is claimed by Toledo Woodhead Springs Ltd, Sheffield 3, England.

As one example of the difference between a conventional and a "rational" spring, TWS cites a 4-leaf unit with a weight of 16 lb 4 oz that has a maximum measured stress of 74,000 psi. A conventional spring designed for similar service (maximum measured stress: 83,000 psi) would require 6 leaves and weigh 23 lb 5 oz.

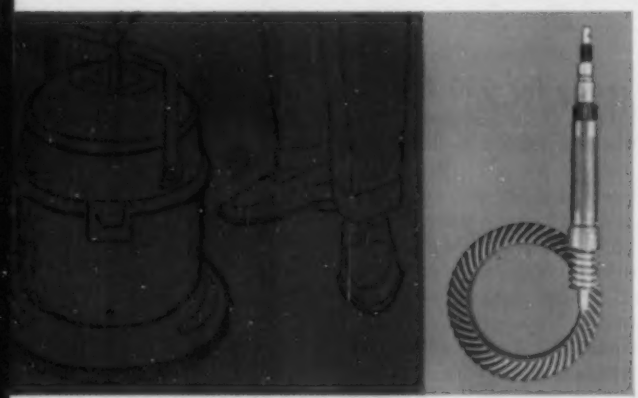
Note: for news of another new British idea in suspension spring design, see *PE*—*May 30, p 8.*



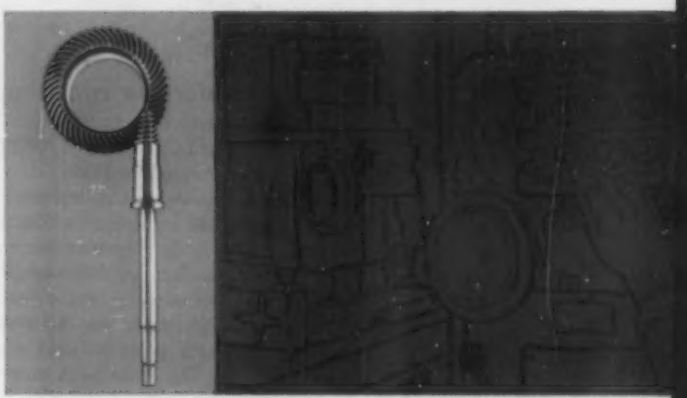
CONVENTIONAL AND "RATIONAL" springs are compared here. Note polygonal shape of new design.



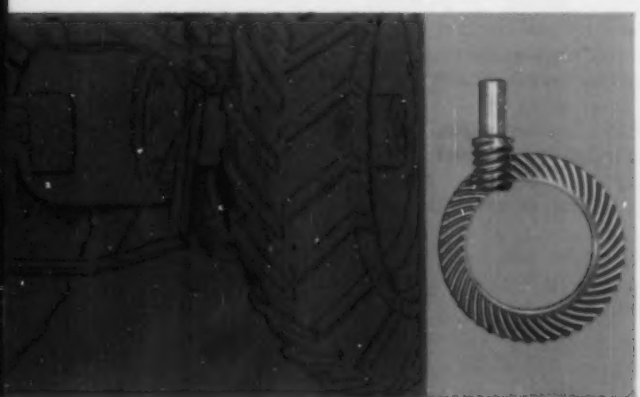
WHICH OF THESE HIGH-RATIO HYPOIDS IS "JUST RIGHT" FOR YOUR PRODUCT?



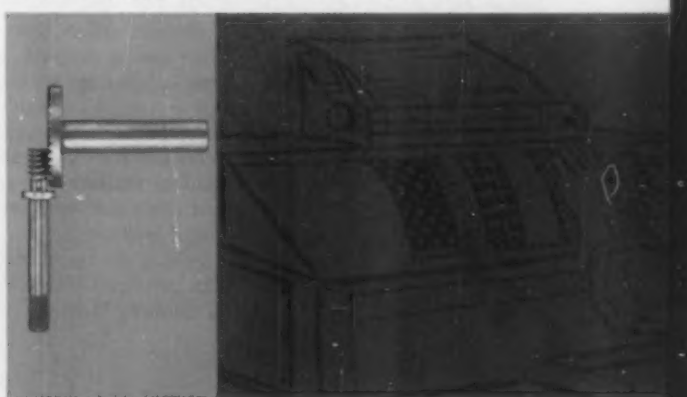
For hand tools. Where space is a problem—as in portable tools like this one—the high offset lets you design a more compact unit. Choose just the offset to solve your design problem with a more flexible, more compact unit than the corresponding worm and wheel.



. . . or machine tools. This high-offset pair lets you combine high reduction with strength, compactness and other advantages you might find profitable in designing machine tools. High-ratio hypoids can be produced on Gleason equipment for ratios of 1:10, 1:40 or even higher.



Big and strong. Where you need strength—as in farm machinery—high-offset hypoid pinions (with teeth which tend to "wrap around") are larger and stronger than corresponding bevel pinions. An extended shank on cylindrical pinions makes very rigid straddle mountings practical.



. . . or small and smooth. For smooth operation—as in office equipment that must run quietly—high-offset pairs provide smooth, quiet tooth action. Because teeth "wrap around" the pinion, you get continuous action—even with just one or two teeth! Grinders are available for applications requiring precision finish.

High-offset or high-ratio hypoids can be cut, tested, and quenched on the same Gleason equipment that is used on more familiar spiral bevel and hypoid gears. You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

Hafnium carbide makes tough, heat-resistant parts

Hafnium, the element that was once just an undesirable companion for zirconium, now turns out to have many virtues of its own. Not the least of these is its ability to form carbides, borides, and nitrides with outstanding heat resistance. The melting point of the carbide (about 7200 F) is exceeded only by a tantalum carbide-zirconium carbide combination, and the melting points of the nitride and boride (both close to 6000 F) are the highest of their types.

Heat resistance alone might not be enough to make these materials worth testing. But they also have useful electrical properties (*PE—Feb 9 '59, p 16*); and recent reports, one from Metallwerk Plansee of Austria, indicate the carbide is tough enough to rate consideration for tool bits. It seems particularly suitable for applications of this type when combined with tungsten carbide, titanium carbide and cobalt, for machining steel and cast iron.

High-voltage, high-energy-storage capacitors ready for 930 F

Storage capacitors with an insulation resistance of 10 megohm-farads, capable of operating at 930 F and 1000 volts dc, and in the presence of high-flux radiation fields, are now being readied for production.

These use boron nitride, hot-pressed on gold-plated iron electrodes, as the dielectric, and are designed to be enclosed in an alumina housing packed with alumina powder.

Well along in development, but not yet considered ready for release, are ultrathermic 5-megohm-microfarad 930-F capacitors using high-purity alumina, flame-sprayed on aluminum electrodes, as the dielectric. Similar designs, using magnesia and boron nitride as the dielectric, are also under test.

Work on both types is being done under Air Force contract; the former by P R Mallory & Co; the latter by American Machine & Foundry.

(Note: For a report on resistors designed for similar conditions, see *PE—Feb 16 '59, p 19*).

New transistor circuit-control for thermocouples, strain gages

Transistorized chopper circuits that show a low and constant rate of drift with temperature change, that can be used over the full temperature range from −65 F to 212 F, and require little or no setup, are claimed by Smith's Aviation of Wembley, Middlesex, England.

Key to the new development, says Smith's, is a new and still experimental symmetrical silicon-alloy transistor with outstanding reliability of performance. Two of these are combined with four resistors and a transformer to make a chopper circuit which, the company reports, is about one-fourth the size of a mechanical chopper and sturdy enough for normal field use.

First application is to be in thermocouples, and strain-gage applications are now under test. The transistors themselves are made by Semiconductors Ltd. and are available from that company in sample quantities.

Soviets use metal-ceramic disks for long-life friction gearing

Steel friction disks, coated and reinforced with a copper-tin-lead-iron-graphite-sand-asbestos mixture, are replacing bronze in multidisk friction gearing for automatic lathes and similar equipment in the USSR.

According to the Soviet publication, *Stanki i Instrument*, the new disks far outlast conventional materials and offer greater uniformity.

Starting point for the new disks is copper-plating the steel in a cyanide solution. This is followed by diffusion burning at 1750 F for 2½ hr in a hydrogen atmosphere.

Next, the metal-ceramic powder (70% by weight electrolytic copper, 9% tin, 6% lead, and 4% each of graphite, iron, and sand, and 3% asbestos fiber) is pressed and sintered, and applied to the steel under heat and pressure (72 to 110 psi). Finally, the parts are cooled to room temperature in a reducing atmosphere. —ARG

WHAT'S HAPPENING IN RESEARCH . . .

Only one particle after all?

If the welter of atomic particles—mesons, hyperons, protons, antineutrons—is becoming confusing, don't worry. There's a new theory at hand that makes the whole business seem simple indeed.

The theory, proposed by J. W. Haffner of Radiation Counter Labs:

There is, in reality, only one elementary particle—call it electron or meson if you will. But it can occupy a great many different self-energy level (quantum) states; and, in each, it takes on a different aspect. This has made researchers think they were dealing with different kinds of particles rather than a single one.

To explain his theory, Haffner has drawn up two Bohr-level (solar-system-type) diagrams showing the various levels or "orbits" in which this particle may be found. One orbital system represents the positive-energy state in which the particles have a negative charge; the other represents the negative-energy state (particles with a positive charge). In the former, when the particle occupies the outermost orbit, it is an electron, and this is the most stable position in this system. At the next levels are the various mesons; with the innermost orbit being an antiproton.

In the other orbital system, the innermost position is the most stable, and when the particle is at this self-energy level, it's a proton.

Haffner emphasizes that this is only a theory, and in its early stages of development. Discussion and amplification will be most welcome.

Electrical and physical measurements made to order

As an adjunct to its instrument rental program (PE—Apr 20 '59, p 14), General Electric's Service Shops Dept is now offering to "measure virtually any electrical or physical qualities, alone or in combination—voltage, current, frequency, pressure, torque, strain, velocity, acceleration—of practically any part or assembly." Take the item to any GE Service Shop and it will be forwarded to Schenectady. You'll get it back, says GE, with complete test data.

Ice fabrics reveal mass flow and crystallization

Glacier ice, says W. B. Kamb of California Institute of Technology, "is a monomineralic rock that has been metamorphosed while subjected to stresses related to the movement of the glacier under the influence of gravity. As with other metamorphic rocks, ice is entirely recrystallized in this process. It is, therefore, possible to apply the geologic technique of petrofabric analysis to the study of glacier-ice fabrics."

That's quite a mouthful, but it does explain why ice "fabrics"—the patterns produced by the spatial relations and preferred orientations of ice crystals—reflect the patterns of stress and strain related to glacier flow.

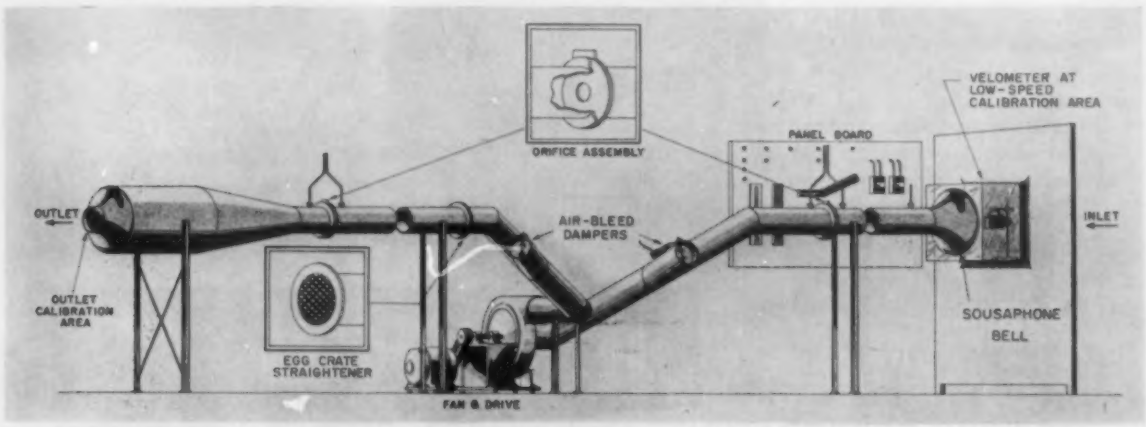
Under IGY sponsorship, Kamb has been studying these patterns, reports texture and crystal studies reveal a good deal about glacial history and movement.

The similarities, in both techniques and results, to mechanical and metallurgical stress-strain and plastic flow studies indicate that one may eventually contribute to the other.

Sounding off for better meters

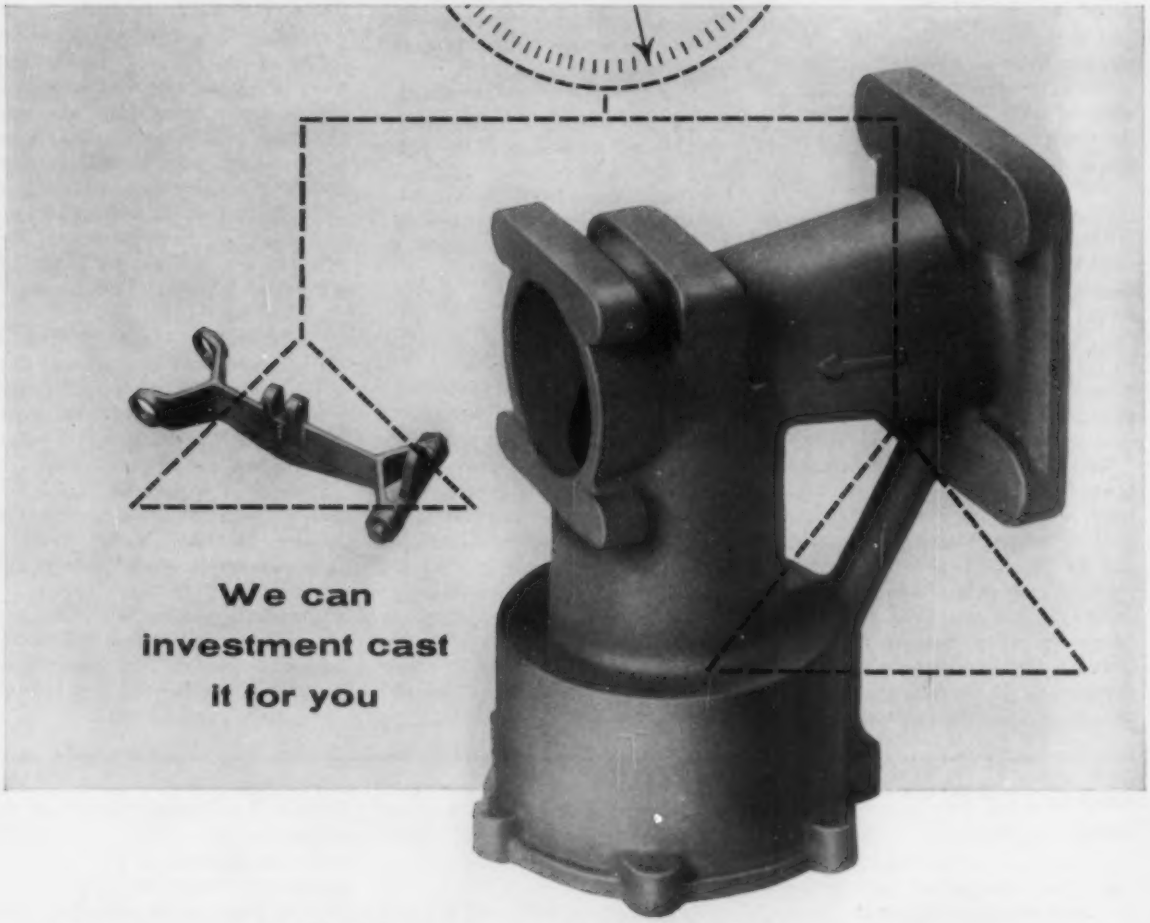
A brace of Sousaphone bells, an "egg crate" straightener, and a pair of pneumatically controlled bleed dampers will give Esso Research engineers a subsonic wind tunnel with "a wider range of air flow than any other unit known"—20 to 5000 ft/min. The aim: better, faster calibration of air-flow meters.

The Sousaphone bells, used at each end of the tunnel, provide the flat profile of air through the tunnel that gives uniform flow through the mouth or calibration area. The "egg crate" baffles also aid uniform flow and help prevent difficulties that might result from the fact that the unit's 8-in. tunnel tube has to snake its way through an attic area. —ARG



SOUSAPHONE BELLS assure uniform flow of air through new wind tunnel built to calibrate air-flow meters.

WHETHER YOUR PART IS TINY... OR WEIGHS 100 POUNDS...



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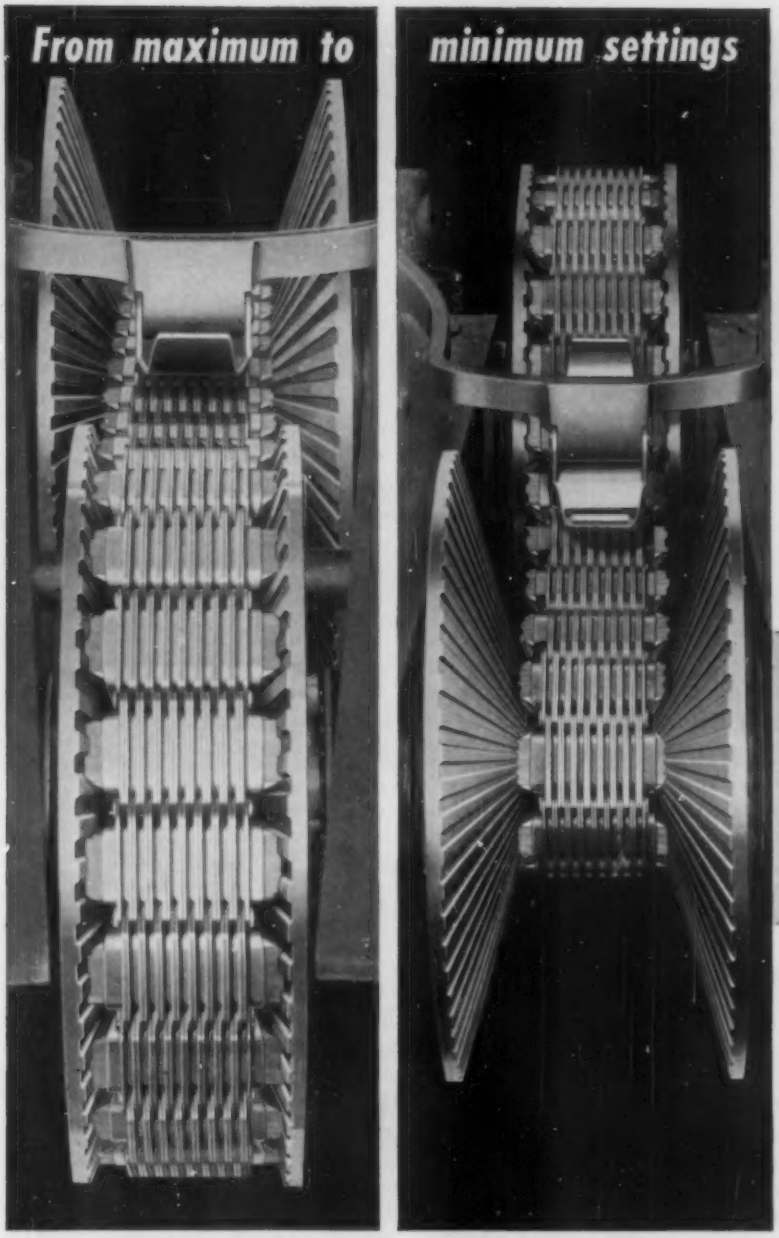
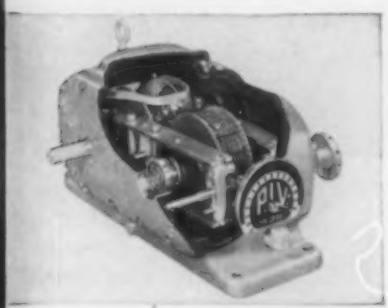


VARIABLE from top speed to minimum speed with no steps, no stops in between. That's Link-Belt P.I.V.—the *only* chain-driven variable speed drive. Teeth—not tension—permit instant ratio changes with no loss of speed, regardless of load conditions.

Slippage? Not a chance—P.I.V.'s chain-to-wheel grip is positive as a gear. In fact, this is industry's most accurate, most reliable mechanical variable speed drive.

Your nearby Link-Belt office will assist you in applying P.I.V. to meet your variable speed requirements. Call today or write for P.I.V. Book 2274 containing complete information on drives from ½ to 25 hp.



HOW P.I.V. WORKS. Exclusive self-tooth-forming chain of P.I.V. consists of packs of free-sliding steel slats which serve as teeth. Chain grips beveled grooves on pairs of conical wheels located on input and output shafts. Speeds are changed by varying the effective diameters of the wheels, as shown at left.

P.I.V. LINK-BELT VARIABLE SPEED DRIVE

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FROM WASHINGTON . . .

High Secrecy Shrouds Our Spy Plane's Photo Gear

The White House has clamped a tight lid on all information related to the U-2 spy plane's camera equipment. But reliable sources say the cameras were made by Fairchild Camera & Instrument Corp. Fairchild won't confirm or deny.

American newsmen in Moscow noted seven glass ports for cameras in U-2 wreckage put on display by the Russians. They also saw a 9 x 18-in. film-size camera with a 73B designation and an astro-tracker for calibrating pictures taken in flight with the sun.

Fairchild has developed a high-acuity subsystem that will photograph a 2-ft-square object at altitudes in excess of 100,000 ft from a plane flying at speeds greater than Mach 2. Dubbed the KS-25, the photographic system is just now going to the Air Force. It could be used in the Lockheed F-104.

The KS-25 may be the follow-on version of the camera equipment used in the U-2. Fairchild won't confirm this point, and the company says cameras designed for subsonic flight cannot be used at supersonic speeds. But the U-2 flew at altitudes from 70,000 to 90,000 ft at just below supersonic speeds.

The Air Force has a study underway to develop a camera with a 36-in. to 48-in. focal length that will show objects as small as 40 ft square from orbital altitudes of 150 to 300 mi. The service won't give out any details of the project, or say how high the resolution will be in the first cameras for the Samos satellites. It's an indication of the goal they are shooting for, however.

New Freezing Process for Fresh Water

A promising new process for converting saline water to fresh by freezing is being developed by Struthers Wells Corp of Warren, Penna, and Scientific Design Inc of New York. The companies are getting a contract from the government to build a pilot plant at Warren. **The process is designed to produce ice crystals about 1 mm dia instead of the 1/10 mm ones produced by other systems.** Bigger crystals simplify the key step in the freezing process—washing and draining the brine out of them. The big crystals are made by closer control of evaporation conditions—pressure, rate of flow through the crystallizer, and depth of the liquid through which butane bubbles.

New Recommendations for Highway R & D

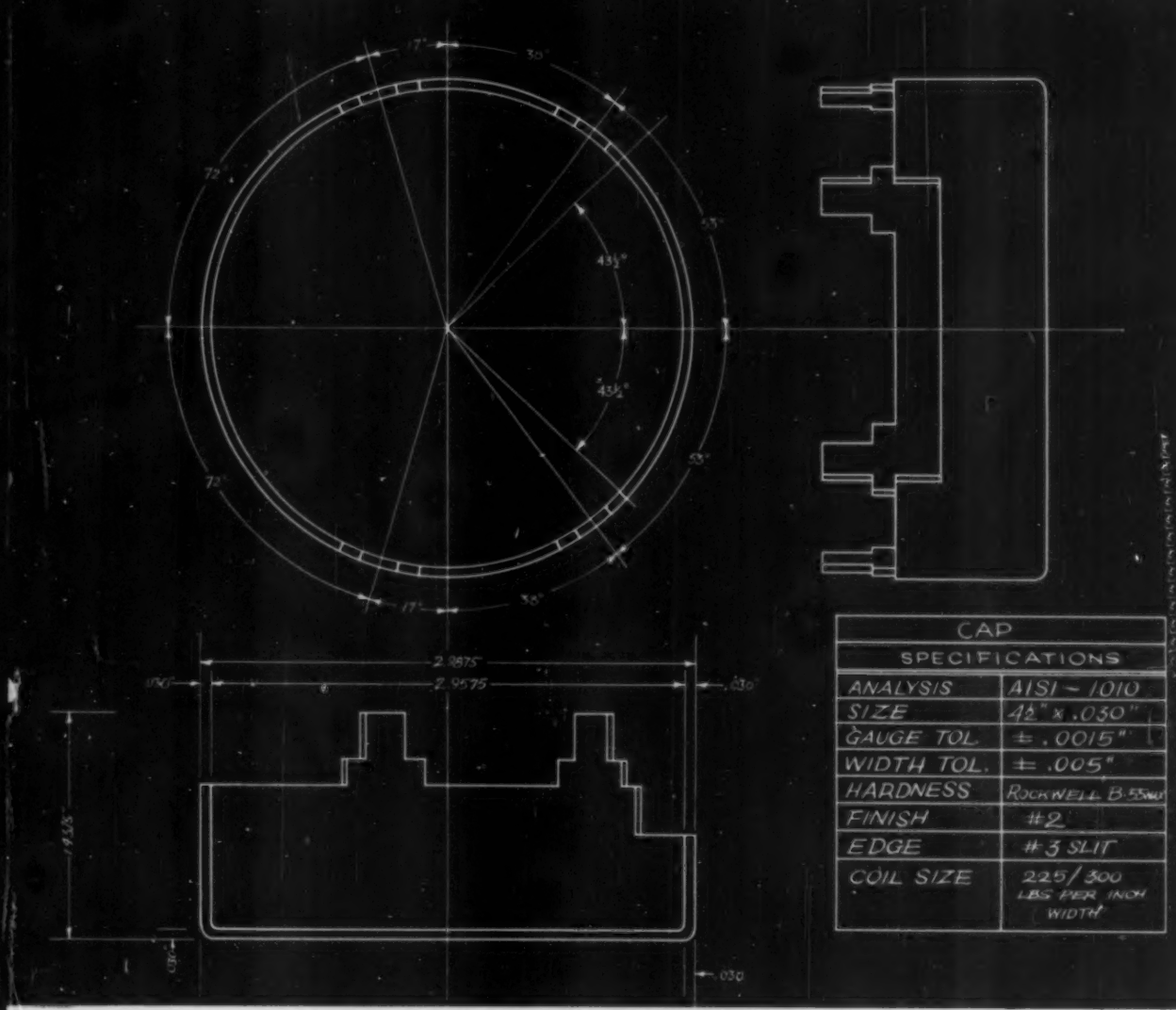
Highway engineers have recommended additional millions for research equipment to study auto safety and highway design. There's good chance that much, if not all, the financing will be forthcoming.

A five-man team made recommendations to the Highway Research Board, part of the National Academy of Sciences. Research on electronic control of vehicles "should be started immediately," the report said, since some electronic aids to driving are already "feasible of adoption." Recommended spending over 4 to 5 years was $3 million.

A driving simulator, with TV tapes of driving conditions, geared to a computer that's programed to driver reactions, is badly needed. Estimated cost is $3.5 million.

All told, the group recommended boosting present highway research of $17.8 million to $52 million. Federal and state funds are allocated to such projects through the state highway departments, the Federal Bureau of Public Roads, and private sources.

CIRCLE 13 ON READER SERVICE CARD →



CAP SPECIFICATIONS	
ANALYSIS	AISI – 1010
SIZE	4½" x .030"
GAUGE TOL.	± .0015"
WIDTH TOL.	± .005"
HARDNESS	ROCKWELL B-55
FINISH	#2
EDGE	#3 SLIT
COIL SIZE	225/300 LBS. PER INCH WIDTH

HOW CLOSE SHOULD THE TOLERANCES BE HELD?

This part may be produced in a ten-stage, progressive stamping die. It will be made from 0.030" low carbon cold rolled strip steel. The normal gauge tolerance is 0.0015" . . . or, a total variation of 0.003".

Is this tolerance tight enough?

Of course, tolerance should be no tighter than necessary for the successful design of the finished part . . . or for efficient, trouble-free stamping. If the part cannot be fabricated with a minimum of production trouble, the tolerance is *not* tight enough . . . regardless of the design requirements of the finished part. In an intricate, high speed stamping operation, a variation of 0.003" could easily result in a high percentage of rejects; could cause frequent down-time . . . constant tool adjustment; could create *needless* production problems.

Why not check your own stamping operation?

Assured optimum production starts with the design specifications . . . with the specification of J&L Precision cold rolled strip steel. J&L can hold gauge tolerances to tenths of thousandths to provide steel which will perform as your design specifies . . . to deliver the maximum yield per pound of steel.

The experience, facilities and accumulated know-how of a specialized organization . . . directed exclusively to the processing of low carbon, high carbon, alloy, tempered and stainless strip steels . . . are available to work for you. For assistance in solving your problems, call your J&L Stainless and Strip Division representative, or write to Dept. 235Y-616.

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The big design engineering advantage of urethane elastomers is their combination of a high hardness range (from 60 Shore A durometer to 65-70 Shore D durometer) with high elasticity (elongation to 800%) which means a combination of working properties that gives you the structural strength of metals with the functional values of rubber.

Urethane elastomers are not merely another type of synthetic rubber; they are chemically-engineered materials with a completely new combination of properties. Properly designed urethane elastomer parts will outwear, out-perform other rubbers, plastics and many metals. Elastomers made with Mobay's Multrathane® line of chemicals have passed severe OEM tests for abrasion, impact and ozone resistance, flexing strength and wear properties.

If you have not yet investigated urethane elastomers for your design engineering requirements, get the facts from Mobay. Ask for the Multrathane Engineer's Manual.

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Mobay supplies Multrathane chemicals and technology for manufacturing urethane elastomers.

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THE ENGINEERING WEEK

Latin America's Common Market; Boost to Product Design and Industrialization

MEXICO CITY—Early this year, seven Latin American countries—Mexico, Argentina, Brazil, Chile, Paraguay, Uruguay and Peru—signed a pact setting up a common market area, or "free-trade zone" as it is called here. In this pact, the seven countries agreed to mutual tariff reductions of 8% each year for the next 12 years. And they will try to curb excessive and costly duplication of new industry by concentrating certain basic industries in selected countries.

This agreement, according to a McGraw-Hill World News roundup, will have a profound effect on the products manufactured in Latin America and on their imports of engineered goods from the US and Europe. Most progressive Latin American companies are considering the opportunities that the proposed market will open up for them. And some are even beginning to design with the new Latin American market in mind.

The market area now embraces 144 million people and may eventually include well over 200 million, if other South American countries such as Bolivia, Ecuador, Colombia and the five Central American countries join up, as expected. The tariff wall that will divide this region from the rest of the world is counted on to encourage nascent industries and protect them from foreign competition. In the past, foreign competition has sometimes been hard on Latin American firms. One Brazilian company developed a sizable market for hoists in Argentina and Chile during World War II, but was forced out after the war by European and US competition.

Official reports, analyzing the potentials for the area, have voiced particularly high hopes for industrial equipment industries and autos. At present, Latin American industry is said to be purchasing about $2.2 billion worth of industrial equipment each year, but only $200 million of this is manufactured locally. Predictions indicate demand for such items will reach $9.1 billion by 1975, with $5.3 billion of it produced inside the market area. As for autos, Latin Americans now own 1.6 million passenger cars—80% of these in Argentina, Brazil, Cuba, Mexico and Venezuela. Though demand for cars is strong, imports are necessarily limited to 115,000 a year because of hard-currency shortages. Annual sales for 1975 are projected at 1.8 million units, with 1.3 million produced in the market area.

NEW INDUSTRIES EXPECTED

As Latin America's amorphous trade areas gradually crystallize into a sharply defined region, new industry is expected to concentrate around Sao Paulo, Brazil; Mexico City, Mexico; and Buenos Aires, Argentina. Each of these cities already has some thriving engineering industries and each is a heavily populated area, hence has large local markets to support initial operations.

The common market group will doubtless have difficulties in reaching agreement on where to locate basic industries—such decisions may clash with national prides. But as now foreseen, the auto industry will probably concentrate around Sao Paulo and Buenos Aires, and perhaps eventually spread to Mexico City. Companies producing petrochemicals and plastics are expected in Mexico and Venezuela, near the large oil reserves. A steel industry is expected in Brazil, Argentina and Mexico, and pulp and paper industries in Central America.

In the past few years, the industrial development of Latin American countries has been impressive. Some of the new and expanding firms are strictly local. Some are branches of European or US firms that have been eyeing this potentially rich market, and are anxious to establish themselves within the tariff barriers. Some are hybrid companies, combining foreign patents, technical know-how and machinery with local money and knowledge of how to do business in Latin America—a combination predicted to become important.

FOUR COUNTRIES PLANNING

In Mexico, the Worthington Pump Co is preparing to sell pumps made

VAST FREE TRADE ZONE emerges in the Western Hemisphere. Darkened area indicates the seven original participating nations: Mexico, Brazil, Argentina, Chile, Paraguay, Uruguay, and Peru. Later on, other nations in South and Central America are expected to join.

COMITA RADIO, designed by Radio Impulsora Mexicana, has distinct advantages for the Latin American market—chiefly, it is inexpensive. One reason for its low price tag is high factory productivity gained by simple adaptations of inexpensive tools. Multiple drill-head (left) makes four holes in one pass. Each cycle requires 5 sec compared with 15 sec before the tool was adapted. Adapted soldering iron (center) fuses body and front together. Plastic body (above) finishes the assembly. Price of this five-tube is $12.

in Mexico throughout Central America and northern South America. A Brazilian plant of the company will handle the southern half of the continent. A host of oilfield-equipment makers are setting up plans: Cameron Iron Works, Dresser Industries, Hughes Tool, Taylor Forge and Joy Sullivan Manufacturing, among others.

In Chile, the Huaschipato steel plant recently expanded and, with its new equipment, is now able to produce steel at lower costs. Exports of sheet to Latin America are expected to surpass the $9.7 million worth shipped between July 1958 and June 1959.

In Argentina, ITT's subsidiary exported about $2 million of telephone equipment to Cuba and Chile in 1958. This country is now self supporting in producing electric motors up to 200 hp. An Export-Import Bank loan to Tallers de San Justo, an Argentine firm, jointly owned by SIAM di Tella, Westinghouse Electric International and others, will finance a new plant for production of 1200-hp generators and 375-hp electric motors for railroad traction equipment, and also power transformers up to 40,000-kw capacity.

In Brazil, Burroughs set up a plant for manufacturing adding machines in 1958. Brazilian demand for the machines has been so great that the company has not yet exported them to neighboring countries. The Burroughs plant also assembles accounting, receipting and validating machines. Brown-Boveri, the Swiss electrical manufacturer, has a plant in Sao Paulo for manufacturing electrical equipment. One of the important products of this plant is hydrogenerators for Brazil's growing hydroelectric-power industry. These generators have been made up to 80,000 kva. The plant also produces single-phase transformers up to 125,000 kva, three-phase models up to 40,000 kva, and complete substations up to 88 kva. It also assembles some equipment from parts sent from Switzerland.

EUROPEAN AUTOS POPULAR

In autos, the Latin Americans generally prefer European designs. The small cars are better suited to Latin American budgets and narrow streets. Among US-designed vehicles, the Willys jeep is most popular. It is small, powerful and easy to maintain. But just about every auto company is trying to cut in on the Latin American market. Until last year, Industrias Kaiser Argentina, a 35% US-owned company, dominated the industry in Argentina. Since then about two dozen foreign companies have asked—and received—permission to set up manufacturing plants. Argentine law requires that foreign firms manufacture almost the entire product locally within five years. The newcomers include Ford, General Motors and Chrysler from the US; DKW, Heinkel, BMC, Fiat, and Citroen from Europe.

The auto industry in Brazil has taken shape for the most part since 1955. GM, Ford, Mercedes-Benz and DKW are among the companies with plants there. Willys is making jeeps, some of which are exported to other parts of Latin America. Volkswagen is manufacturing a small truck, which will be exported to the US.

As yet, not too many US plants manufacture components in Latin America for export and assembly in the States. But there are some cases: Motorola makes antennas and aerials in Mexico for shipment to the US; Lenkurt Electric makes condensers that involve considerable handwork; and Ciosa, a Mexican company with US interests, ships tools and dies to America. In Brazil a large foundry with US interests, ships small orders of locomotive wheels to the States. Railroad-car production is an expanding industry in Brazil.

DESIGN BECOMING INDEPENDENT

Perhaps the most significant trends now observable in Latin America are a growing independence in engineering design and the development of products specifically for the Latin American market. Radio Impulsora Mexicana has designed a small, five-tube radio with plastic body that will sell for about $12. Among its advantages for this market are: simplicity—almost any repairman can set it right; and versatility—the model has a specially designed transformer-input section, which can be easily adjusted to any supply voltage. This is important in the Latin American market because there are a wide range of voltages. The company sells models of its Comita radio in Central America and plans

an assembly plant in San Salvador. This company has also developed a transistor radio for consumers in areas without electricity, and a cheap refrigerator.

Industria Electrica Mexicana, a company in which Westinghouse has 12% interest, has developed and patented some products on its own. One is a cheap gas stove with jet burner made inexpensively from local materials. IEM expects to sell this utility model throughout Latin America at a low price. The company has also developed a special tropical insulation for its refrigerators. Made of expanded styrene beads, the insulation is said to maintain uniform temperatures inside and prevent cabinet sweating in tropical climates. IEM, however, expects heavy electrical equipment, such as transformers and switches, to constitute the staple of its Latin American sales. Such equipment will have to be specially designed for the range of voltages.

MARKET PLANS NOT FIRM

The free-trade zone is still very much a paper plan. But signatory nations have agreed to a schedule for implementing its proposals. Next month, the various countries involved will let each other know what items they wish to export. And by October 1, each of the nations will announce what items it will accept for tariff reduction. A formal meeting in November will draw up official import-export lists.

As implementation takes effect, the US and Europe will probably notice a decline in their exports of radios, TV, autos, trucks, plastics, machinery, railroad equipment, small ships, motors and light aircraft to Latin America. But the higher standard of living and emphasis on industrialization in Latin America will probably increase the area's net demand for heavy industrial and electrical equipment, cranes, equipment for steel and aluminum plants, equipment for the oil industry, jet and military aircraft and other heavy transportation equipment. But for all these products, US producers will have to compete with European, Japanese and even Russian sources for the Latin American market. Hence, US companies producing in the European market (PE—Dec 21, p 21) may reap additional benefits. ■

Precision Dimpling Possible With New Portable Machine

SEATTLE, WASH—A portable dimpling machine, which operates in areas formerly inaccessible to such equipment, has been developed by Boeing Airplane Co. The new tool, weighing 6 lb and hydraulically operated, is capable of forming dimples for $\frac{3}{32}$- to $\frac{1}{4}$-in.-dia fasteners in 0.020-0.050-in. sheets of aluminum alloy 7075-T6 and 0.020-0.064-in. sheets of alloy 2024-T4.

Dimpling involves the forming of shallow, dished-out depressions around holes drilled in sheet metal. On airplane skins, these dimples help achieve aerodynamic smoothness in riveted areas. On bulkhead panels and other structures, they permit surface flushness. The process normally occurs early in the production sequence, when sheets or sections are small enough to be handled on stationary dimpling machines located in the shops.

In final assembly and later modification and repair work, however, dimpling can become a major problem. Commercially available C-yoke design tools can be used only at points within about 6 in. from the edge of a sheet or panel. When dimpling is required elsewhere, it has been necessary to remove the affected part or skin section from the airplane and take it back to the stationary dimpling machine in the shop.

Boeing's ram-coin dimpler gets away from the restricting C-yoke. It utilizes a separate assembly, which includes the dimpling die and a clamping device known as a split-nut collet-chuck. The assembly also includes a spring-loaded ram with preset action to check and prevent excessive flow of metal in the dimpled area.

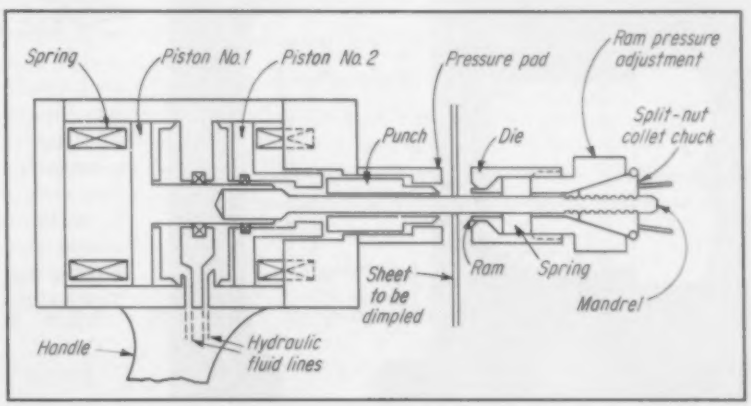
Heart of the tool is the "pull shaft" or mandrel. Slender, yet impervious to a pulling force of more than four tons, the mandrel is made of high-strength tool steel—SAE H-11—that gives it an extremely high yield strength. At one end, threads are cut to a depth of 0.005-in., ± 0.0005-in. This permits easy attachment of the separate inside the clamping assembly without materially reducing strength of the shaft. The other end is enlarged, with standard $\frac{3}{4}$-24 NF thread for attachment to the tool.

Mandrels are interchangeable for forming dimples of different diameters and can be used indefinitely at room temperature. When used with heated dies, useful life is about 25 hr at 700 F.

In operation, the tool produces

continued on page 20

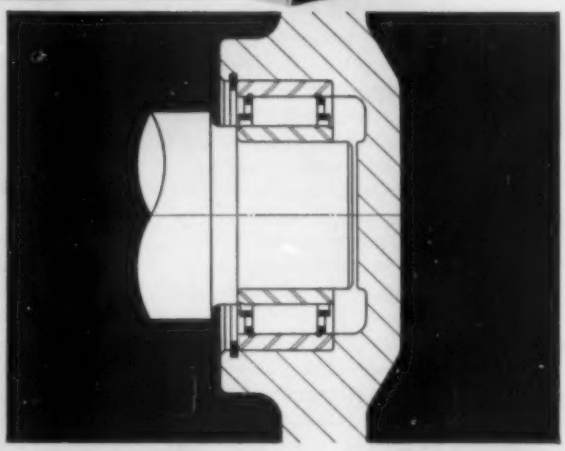
MANDREL of portable dimpling machine, developed by Boeing Airplane Co, is being inserted in a simulated panel from the outside while the split-nut collet-chuck is being positioned and placed on the mandrel from the inside of the panel.

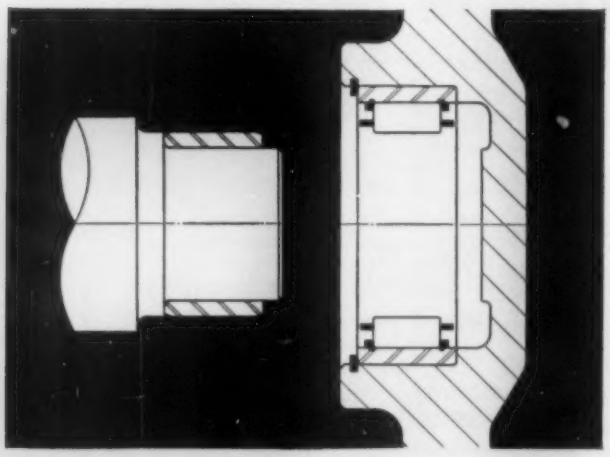


DESIGNS WHEN

SAVES COSTS

Notice how simple this speed reducer becomes when you start using Hyatt Hy-Roll bearings. It's easy to design, quickly drawn and requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be affixed to the shaft with a heavy press fit . . . to become, for your purposes, actually part of the shaft. Since Hyatt Hy-Roll races are made from case-hardened, low carbon steel, rather than through-hardened, they will never crack or come loose.

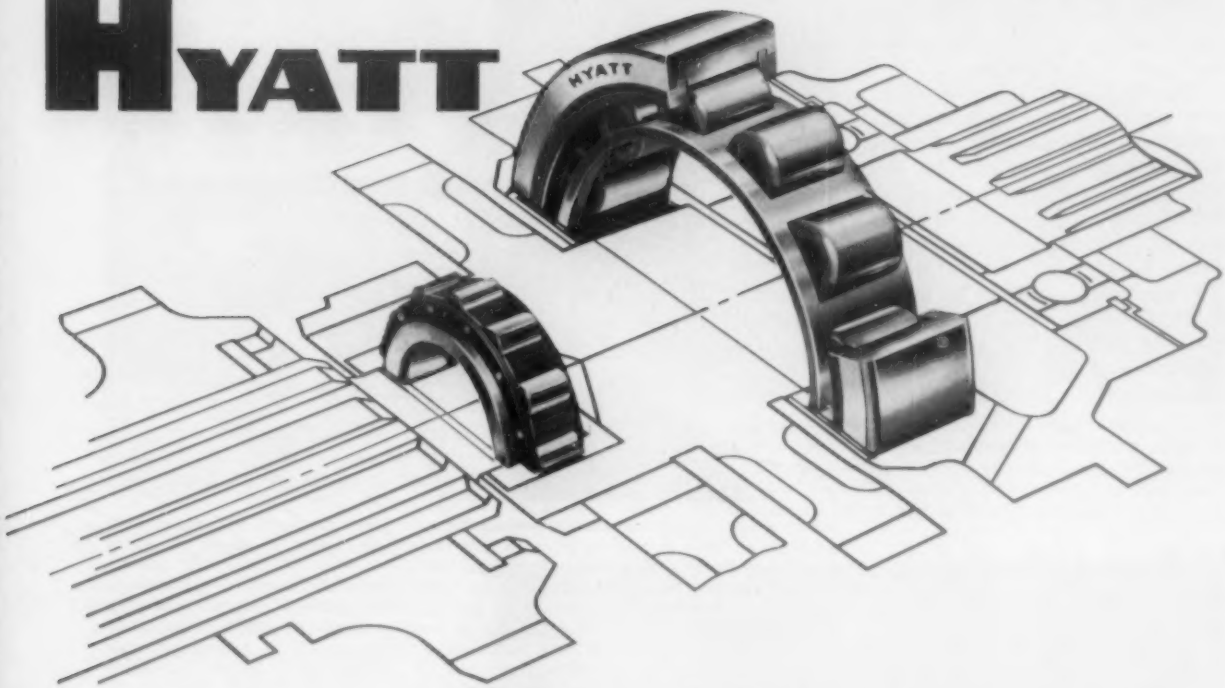




SPEED-UP PRODUCTION

Look ahead to the time when this same speed reducer goes into production. Then you'll see why Hyatt makes all separable races interchangeable within the same part number. For it allows you to press the race on the shaft at one work station, then fit it into any of the mating assemblies already installed in the housing at another station. You don't have to worry about matched assemblies because Hyatt has made selective fits a thing of the past. Think of the time it saves!

CAN BE SIMPLER YOUR "SPECS" READ HYATT



SAVE SPACE

Here's the type of design problem you'll see every day. The horsepower has been increased, so this transmission input shaft must have a larger diameter and the pilot bearing must have added capacity. Yet both modifications must be made *without an increase in overall dimensions.* Sounds difficult, doesn't it? But only until you start using Hyatt Hy-Roll Bearings with separable races!

For increased bearing capacity, use a larger Hyatt BU-type bearing at the pilot and eliminate the outer race. Then specify a Hyatt TS-type bearing for the input shaft. By eliminating the inner race, you have more than enough room to increase the shaft diameter. And both changes are made without increasing the size of the gears or the housing! This is the perfect solution wherever you can harden and grind the mating surfaces to bearing race specifications.

Hyatt produces 10 major bearing types—four have separable inner races

—four non-separable

—and two have separable outer races.

The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the bearing surfaces can be brought to suitable hardness and finish.

For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt sales engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY

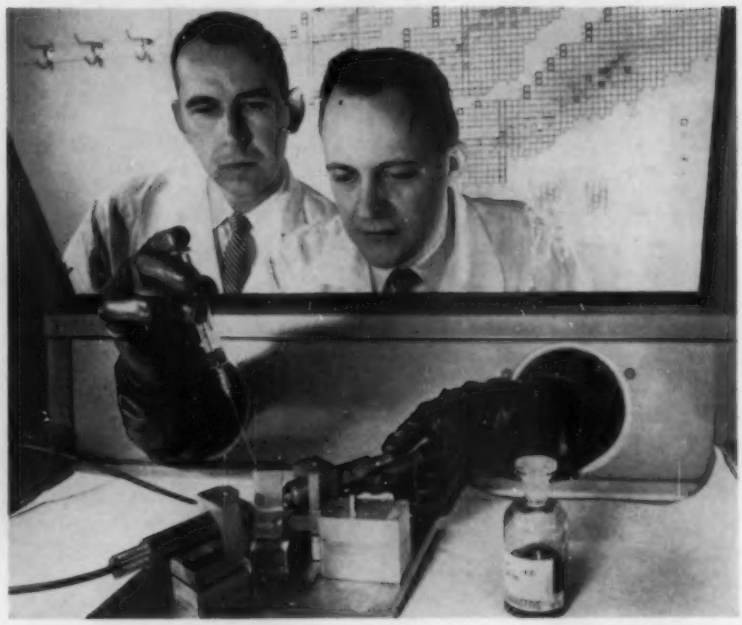
continued from page 17

crack-free dimples by a two-stage pulling and pushing action. The tool, with mandrel attached, is inserted into a hole from the outside. The clamping assembly is slipped into the mandrel from the inside and firmly positioned against the underside of the material to be dimpled.

Two concentric piston-and-cylinder units are independently actuated and controlled for forming various metal thicknesses and diameters. In the first stage, a preset squeeze is exerted on the material; in the second, a punch is projected into the die, forming the dimple.

A unique application of the tool is in tube dimpling. When dimpling beyond the reach of the operator, an extension is used merely to locate the chuck inside the tube so it can be slipped onto the mandrel. The chuck is easily released and removed after the dimple is made. ■

Liquid Isotope Reveals Variations in Metal Thickness



After a low-energy radioisotope—samarium 153—is dissolved in hydrochloric acid, the solution is used to measure tiny variations in wall thickness of engine components made of nickel-base alloy. Technique was developed by Allison Div. of General Motors specifically for determining thickness of an experimental turboprop engine's vanes and blades. Solution fills a hollow blade with radioactive fluid so that radiation energy can be measured through the blade walls. GM engineers hope this technique can be applied to measuring wall thickness of other small hollow extrusions or castings with design intricacies that make conventional gaging impossible.

S.S. France on the Way

Launched at St. Nazaire is the French Line's 1035-ft liner France. The 68,000-gross-ton vessel has a top speed of 31 knots; two of its four screws give 23 knots. The vessel's 160,000-hp propulsion plant is split into two autonomous halves, consisting of four boilers and two geared turbine sets, driving two propeller shafts. In the event of major compartment flooding, either fore or aft, the remaining propulsion unit could drive the ship. The electric powerplants for the ship's services are also divided and separated. Compared to her famous predecessor Normandie, the France is faster, using same hp but less fuel.

Senator Hits "Giveaway" of US Patents

WASHINGTON—Sen Russell Long (D-La) said he is introducing a bill requiring the government to claim all patents resulting from government-financed research and development.

In a Senate speech he contended that federal policy now surrenders valuable patent rights for new processes and products developed or invented at government expense.

"The patent policies of the Defense Dept and the National Science Foundation constitute a giveaway program which makes the Teapot Dome scandal of the Twenties seem like a penny ante game," Long said. ■

British Coordinate Metallurgical R & D

LONDON—A National Information Center for correlation and dissemination of data on creep and fatigue in high-temperature metals will be set up by the Dept of Scientific and Industrial Research (DSIR) at the National Engineering Lab, East Kilbride. All British metallurgical research organizations will submit experimental data to the center. This data will be reduced and presented to users and designers in a prearranged form. ■

NSF Appeals to Libraries, Information Centers

WASHINGTON—The National Science Foundation is urging all scientific and technical information centers in the US to contact Battelle Memorial Institute to ensure their inclusion in a proposed directory of such centers as soon as possible.

Because the value of such a compendium depends upon its comprehensiveness, the NSF asks all information centers to send name and address to William H. Bickley, Battelle Memorial Institute, 505 King Ave, Columbus 1, Ohio. ■

Numerical Control Without Numbers

CLEVELAND—A new numerically controlled turret lathe, unveiled here last week by Warner & Swasey, includes its own electronic memory designed to store and recall the sequence of commands of any machining cycle and to put the various feeds and motions into action automatically.

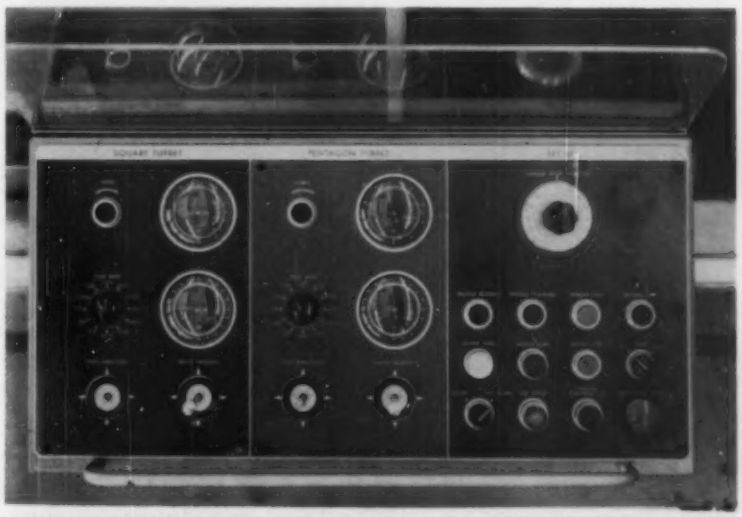
The machine's controls are all-electric: the operator's console has no handwheels and the dial indicators showing turret movements are built right into the console. Servo-powered joy-sticks can be pushed in any of four directions and the turrets will be driven in the chosen direction at a speed proportional to lever movement.

The automatic-control mode of operation requires no outside programing. The operator runs through a machining cycle on manual control and after each acceptable cut simply pushes a button to record the action in the memory. Feed, speed, start-of-cut, length and dimension on the work are then permanently recorded.

There is provision for changing individual commands as tool wear or some other variable calls for a modification. The operator allows the cycle to proceed to the cut needing alteration. He then switches the machine to manual control, makes the desired change, presses the record button, and returns the machine to automatic control—the old commands have been erased and the new ones substituted. Corrections of 0.0005 in. in the horizontal direction and 0.000,25 in. in the cross direction can be made.

A method of producing contour cuts is also included in the control system. A prepared tape carries the sequence of motions and the memory draws on this information once the precise starting point of the contour has been reached. When the contour has been completed, the tape signals a return to the control's normal memory for next set of instructions. ■

NEW LATHE has two turrets inclined 20° from the vertical. Foreground: the pentagonal indexing turret; in background (behind the shield), a smaller, square turret. Operator's control console is mounted on front rail of the machine, can move along this rail independent of turret position The headstock control center sets automatic modes and controls memories.



FRONT RAIL CONSOLE has independent control areas for each turret and for basic machine setup. Dial indicators are remote electrical repeaters showing changes in turret motion. Graduated in 0.001-in. increments, they can be read to 0.0005 in. At bottom of each turret-control area are two joy-sticks that control direction and speed of turret motion by direction and inclination.

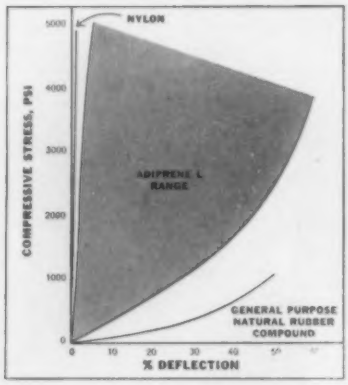
Compressor-disk Wheel Trouble Grounds British Airliner

LONDON—The bursting of one of 15 compressor disks in a Rolls Royce turboprop engine has grounded Britain's newest big airliner, the Vickers Vanguard. Examination of other engines awaiting delivery revealed cracking in one other disk. Similar failure in the air could be disastrous, since the unit spins at high speed and pieces breaking off have been known to shatter an aircraft's wing.

This is the first time that the 5000-hp, high-temperature Rolls engine has had any serious trouble despite its advanced features. Most likely cause appears to be a variation in a batch of disk metal. If there is no inherent design defect, chances are that at least three Vanguards will be entered into service next month by British European Airways on its London-Paris route. ■

ADIPRENE® L

new Du Pont liquid urethane elastomer



CARRIES A HEAVY LOAD An outstanding attribute of this new Du Pont synthetic rubber is its combination of toughness, high load-carrying ability and resilience. Load-bearing capacities of hard ADIPRENE L compounds far excel those of general purpose synthetic rubbers.

RESISTS ABRASION Both in the laboratory and in actual service, ADIPRENE L has demonstrated its ability to resist wear. On industrial wheels it has outlasted natural rubber as much as 10 times . . . has more than doubled service in pump impellers handling abrasive slurries.

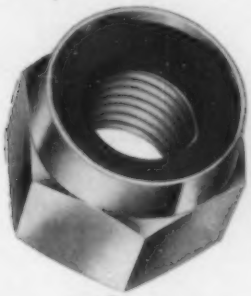
NOT BRITTLE AT "EIGHTY BELOW" ADIPRENE L vulcanizates maintain their resilience at –20° F. . . . and do not become brittle at temperatures as low as –80° F. They exhibit outstanding resistance to thermal shock, and will operate at intermittent temperatures as high as 250° F.

OTHER PROPERTIES Products made from ADIPRENE L are available in various hardnesses from 10 to 99 Shore A (78 Shore D). They resist the action of lubricating oils, greases, weak acids, alkalies, as well as oxygen, ozone and radiation. Suggested uses for ADIPRENE L include industrial rolls, motor mounts, seals, potting compounds, solid tires, striker plates, wear-resistant linings and coverings. Write for booklet on properties and applications of this new material. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. PE-6, Wilmington 98, Delaware.

DU PONT SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®
Better Things for Better Living . . . *through Chemistry*

UNSHAKEABLE SELF-LOCKING PERFORMANCE IS BUILT INTO AN ELASTIC STOP NUT

Start with a standard hex nut and add a metal crown . . .



Add "the ring of reliability"— the easily identified ESNA red nylon locking insert . . .

Then roll the crown over smoothly and stake— the insert is made an integral part of the Elastic Stop nut

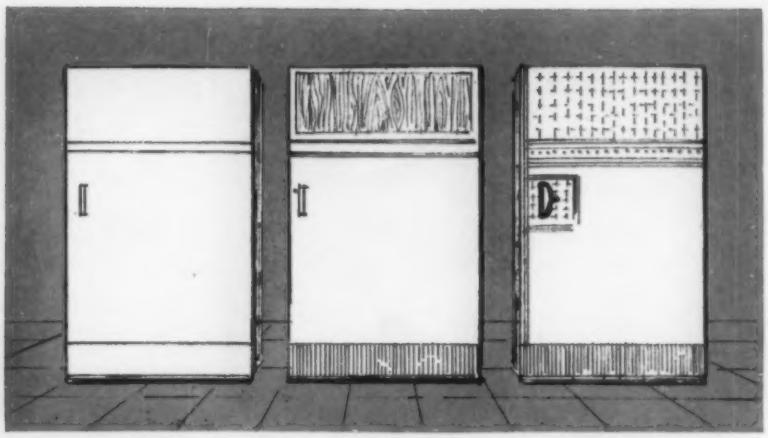
BUILD FASTENER RELIABILITY INTO YOUR PRODUCT!

Take an Elastic Stop nut and mount it on one of your products where vibration is really severe. Shake the daylights out of it in the roughest torture test you can devise—or better still—send it into the field where it's subject to regular use and abuse.

Here's what you'll find: That Elastic Stop nut will stay put! The bolt threads are impressed into the nylon locking collar with such a perfect fit that internal liquid seepage is sealed off. Internal nut and bolt threads are protected against corrosion. The nylon insert locking torque is so smooth that it never galls or distorts bolt threads; and nylon is so wear-resistant that under normal usage *you can wrench the nut on and off the bolt 50 times or more* and the nut will still remain tight under vibration! Protect the performance and the reputation of your product by guaranteeing fastener reliability. Try it yourself and see. Send for free test samples. Just tell us the size. Dept. S53-645, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

ESNA® **ELASTIC STOP NUT CORPORATION OF AMERICA**

THE YEARLY MODEL CHANGE MUST GO!



J GORDON LIPPINCOTT
Lippincott and Margulies, Inc., industrial designers, New York City

■ There simply isn't enough creativity within industry to produce what are truly innovations in outward design each year. This is true whether the products are refrigerators, automobiles, washing machines or anything else. Neither is it possible to come up with something new and different in a mechanical sense each year, despite the advances in technology.

Yearly model changes have to some degree downgraded the function of the engineer—even in the eyes of the engineers themselves. After all, it is hardly stimulating to be told that your work is not appreciated by the consumer—that all the consumer buys is the glossy, streamlined outside.

The annual re-do also has had its effects on the industrial designer. The design of many products becomes a kind of millinery type of operation. Style changes are made merely for the sake of being different, not for being better. I am sure that engineers as well as designers have observed many products that were well designed from an appearance standpoint when they started out. Then, the following year, the design is rearranged; yet the inside and even the function remain substantially the same. The rearranged design is almost always worse in appearance than the original.

If you talk with engineers and designers you find them resenting the fact that the products could be made better if retail figures that must influence the quality of components were not insisted upon.

Obviously those people concerned with manufacturing would also like to see the yearly model dropped. No one likes to set up an assembly line and sources of supply and see them upset every year. Particularly when they know in their hearts that the changes don't amount to much. Manufacturing could also do a better job of quality control if they were not plagued with the yearly model.

Another penalty of introducing a model every year is that they come out too fast for de-bugging. Several years ago we were working with an appliance manufacturer. To meet a marketing requirement of a new yearly model, the client put out a new model—riding over the heads of his research group, simply to meet a marketing deadline. The model had to be withdrawn from the market because it had so many bugs in it.

The yearly model undoubtedly has been a marketing

stimulant. We know that when the word "new" is added in a big yellow patch to a package, it generally increases sales. But we suspect that the consumer is beginning to have doubts. There are indications that the consumer has seen the big yellow patch shouting "new" too often on too many products that were really not new.

This possibly was the biggest criticism of the Edsel automobile. With all its advance publicity of being an entirely new car, when it was finally launched, it was just another automobile with a new configuration of chrome.

By contrast, observe the Volkswagen ads, where the main appeal has been that there are no yearly model changes. This is one of the first cracks in the dike, indicating appreciable numbers of American consumers would prefer not to have a yearly model.

There have always been marketing problems in yearly models, such as how to sell the obsolete model without cutting the price. After a time, the necessity of doing this affects consumer attitudes toward list prices.

Does this mean that there may be a connection between the growth of discounts in retailing and the yearly model change? We think there is. We think that the yearly model, while it has stimulated marketing, also has had its unwholesome side-effects–and these are now beginning to catch up.

There is no doubt at all that yearly model changes have created great problems in distribution–particularly in inventory. Let me give you an example:

Last month, our dishwasher motor burned out. We chose this particular make of dishwasher because my wife knew they have the most satisfactory service facilities. But despite the fact that we live just outside New York City, and despite these excellent facilities, it took over a week for the service man to get the dishwasher operating again. He did not stock the parts and apparently there was difficulty in even getting them out of New York.

We have also had the experience of having an appliance only five years old made useless because the model had been discontinued. The parts for a relatively simple repair were no longer obtainable.

The pressures inherent in the marketing concept of the yearly model have brought about excessive gadgetry in our products. There are too many pushbuttons on our washing machines and dryers. They may save a small amount of labor on the part of the operator but they all make the product more complicated. They are all points at which the mechanism can break down.

An example: pushbutton controls to raise and lower auto windows. Now it's true that a window will go up and down easier with pushbutton than with crank and handle, but is it sufficiently better when you consider it as a maintenance item? I recall that on a car I owned, I spent over $150 in just one year having these window-raising mechanisms repaired.

The problems of getting these repairs accomplished overseas are immense. A friend of mine, who lives in San Salvador, owns a coffee plantation. He tells me that when a record player or a portable air conditioner breaks it is cheaper to throw the entire unit out than try to get it repaired down there in Central America. He simply won't buy most American products because of the difficulties of getting them repaired.

When I asked about products from other countries, he replied that they are better engineered. And he thinks this is because their goal has been simplicity and reliability. In talking with others last winter in San Salvador I was surprised to find that they are now buying such mechanical products as typewriters, radios, refrigerators and automobiles from countries other than the USA. One man remarked that only in the area of roadbuilding and earth-moving machinery is the US still ahead of other countries –it is interesting to note that such products are still largely uninfluenced by the yearly model concept.

These people admitted that price had much to do with it, but they also felt that other countries' manufacturers had a better understanding of the needs of a foreign market than American companies.

It is a cinch that getting rid of the yearly model change –or planned obsolescence–and changing back to a common-sense system could not possibly occur overnight. For example, neither Ford, Chrysler or General Motors can suddenly announce individually that there would no longer be yearly model changes. For them to do so when their competitors did not, would put them at a serious marketing disadvantage.

I feel the change is most likely to begin with one of the Big Three bringing out an automobile advertised as a model that will not have yearly changes. There would be substantial market for this car, particularly if the consumer is told that the savings will be passed on to him.

The consumer should also be told and will readily understand that if there are no yearly changes the bugs will be gradually engineered out of the car and that more money can be spent in higher quality components.

After several years the economies of not having a yearly model would become apparent to the American consumer. It is conceivable that after a period of time most of the automobiles sold might not be yearly models.

Once such a situation developed, how and when would genuine innovations be introduced? When you were ready to introduce them–and not on a timetable imposed by the demand for a yearly model change each fall.

I don't think the abandoning of style obsolescence for the yearly model would slow down innovation at all. Quite the contrary. I believe it would further stimulate it. Furthermore, the wise manufacturer would be the one who would not put out an innovation unless it was genuine and well proven.

This means the manufacturer could devote more of his engineering time and manufacturing talent to creating a well-engineered and reliable product. In other words, spend more on the inside and less on the outside. ■

DOW

NEWS ABOUT
PRODUCT DESIGN
AND
MATERIALS

The happy marriage of modern plastic materials and mass production techniques has been a boon to product designers. With economical production methods assured at the outset, they have been able to take many new and original plastics materials from the research labs of Dow and blow, squeeze, mold and extrude them into products with built-in durability, color appeal, and the "tomorrow" look. Here are some ideas . . .

DESIGN AROUND HEAT, IMPACT, CHEMICALS, WITH DOW PLASTICS MATERIALS

Each of the members of the Dow family of thermoplastics has its specialties . . . and each member's specialties can be further compounded into formulations that highlight one or more strong features. The result: A wide range of highly specialized plastics with such features as economical production . . . high impact strength . . . high heat resistance . . . exceptional moldability. Take fan wheels molded of Tyril® for instance . . .

An excellent balance of physical properties—with special emphasis on high critical elongation and good heat resistance—qualify Tyril for the vigorous, on-the-job performance requirements of a condenser fan wheel.

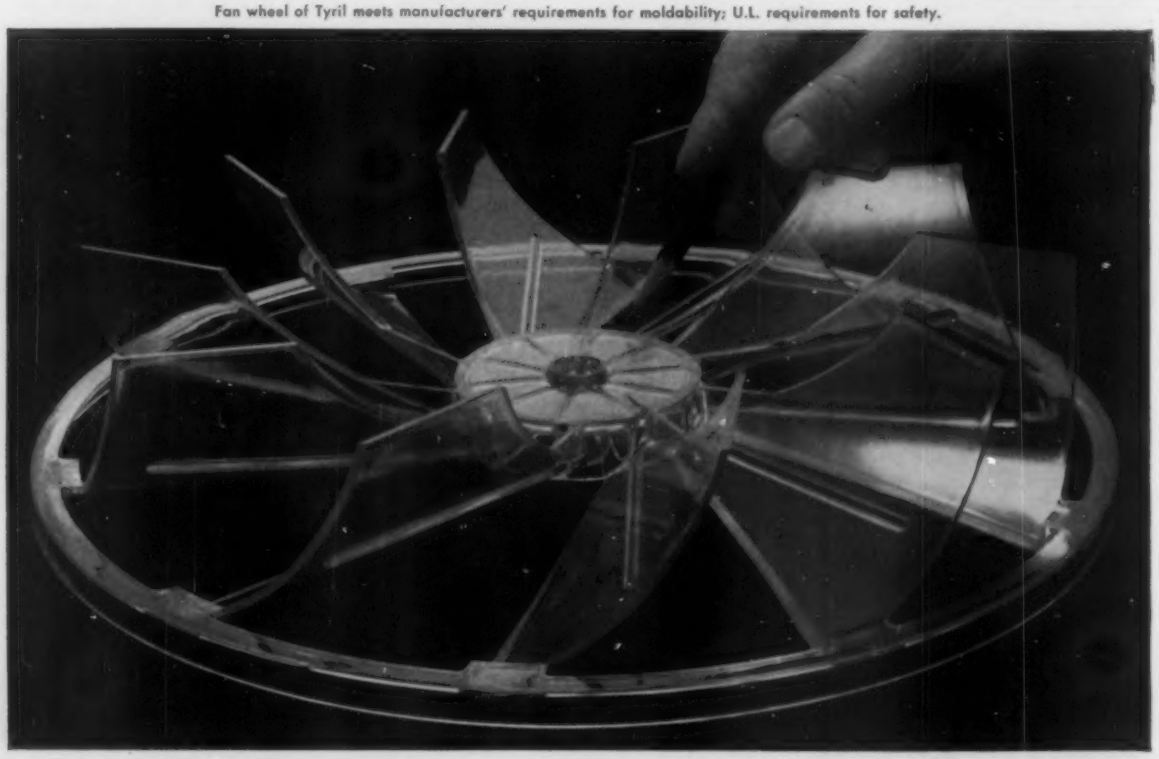
A Dow copolymer of styrene and acrilonitrile, Tyril provides the exceptional molding characteristics required to reproduce the complex configurations, reverse curves and angles of the mold; and to maintain the high axial accuracy of the fan wheel in operation. The high tensile strength of Tyril minimizes creep and cold flow. And in production, faster cycling and better moldability result in marked economies for the manufacturer.

Heat resistance, too, is an important feature of Tyril in this and other applications. In fact, by successfully withstanding the high temperatures of a condenser housing, this fan wheel made of Tyril has the approval of the Underwriters' Laboratories.

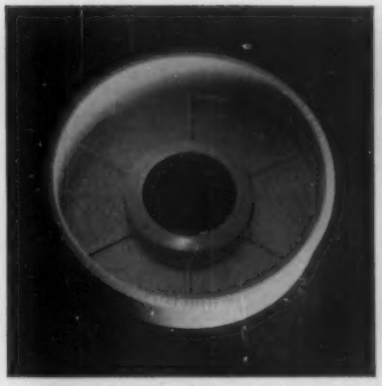
The outstanding performance characteristics of Tyril are currently making it the favored Dow thermoplastic for such products as tumblers, cutlery handles, bristles, filter bowls, rigid food containers, closures, pencil barrels, medical equipment components, and sprayer heads.

Mouth-to-mouth resuscitation takes a giant step forward with the introduction of this unique mouth-to-mask resuscitator. This handy device relies on the special properties of several thermoplastic materials in its design.

Fan wheel of Tyril meets manufacturers' requirements for moldability; U.L. requirements for safety.



Resuscitator relies on a variety of plastics.



Lint filter of heat-, chemical-resistant Styron 440.

Rotary card file of shock-resistant Styron 440.

Both the patient's and operator's mouthpieces are molded of Styron® 440 to take the hard knocks of emergency use and for the good fabricating qualities of this plastic material. The resuscitator tube and the catheter tube are of vinyl formulations. The "airway" for keeping the patient's throat clear is molded of tough moisture- and chemical-resistant polyethylene. And the aspirator jar is also molded of Styron 440, a high-impact, high-heat resistant formulation.

When washday rolls around, this same versatile formulation – Styron 440 – is ready, willing, and able to meet the challenge of today's automatic washers. Lint filters and other parts molded of Styron 440 have the extra tensile strength to withstand years of rugged service . . . the chemical and heat resistance to shrug off effective laundry detergent, and high water temperatures.

Another example of versatile Styron 440 in action is the rotary card file above. Styron 440 gives it extra impact strength. It won't warp, nor will rough treatment affect the appearance of the tough, lustrous case. Inside, ribbed separators keep the cards in order . . . ribs that can be formed accurately thanks to the excellent moldability of Styron 440.

Everyone's an old master when he rolls up his sleeves and goes to work on a numbered oil painting set. The latest of sets has individual paint jars molded of Tyril. This rigid material was selected for its ability to reproduce fine details—especially in the molding of the screw-top threads and grooved bases of the paint jars.

Other characteristics of Tyril make it the ideal thermoplastic material for a car compass housing. Tyril meets the tests for ruggedness and nonmagnetic qualities . . . and it is resistant to chemicals and distortion over a wide temperature range.

The aristocrat of plastics, Ethocel®, has been elected by the manufacturer of these accurate, low-cost split image transits. Extremely high impact strength for rugged service, and superior dimensional stability that keeps the lens accurately positioned in one place were the recommendations for Ethocel in this application.

Individual paint pots are molded of Tyril.

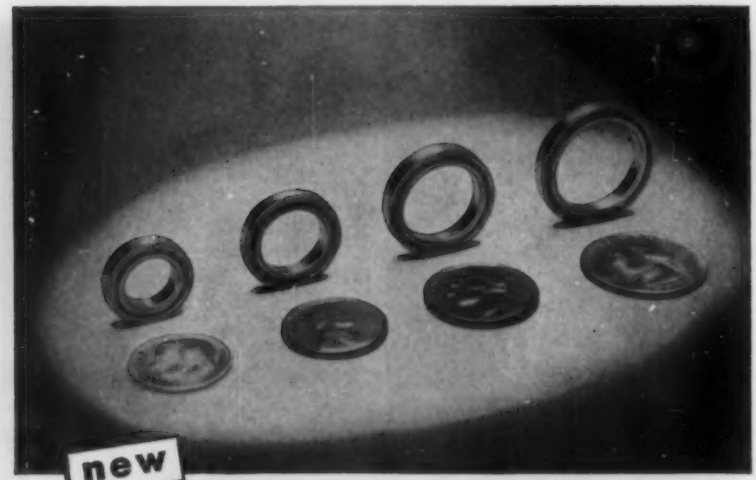
Low-cost transit protected by Ethocel.

Compass housing of rugged Tyril.

HOW ABOUT IT? Have you taken a close look at your products lately in terms of (1) the new and original plastics from the research labs of Dow, (2) the new formulations and applications of the established Dow plastics, or (3) the new economies in production techniques? An examination today might mean greater sales appeal and more efficient production tomorrow. If we can be of any assistance—from selecting the right formulation for your product, to assisting you in color styling—please write The Dow Chemical Company, Midland, Michigan, Plastics Merchandising Department 1719DZ6-13.

THE DOW CHEMICAL COMPANY
Midland, Michigan

DOW



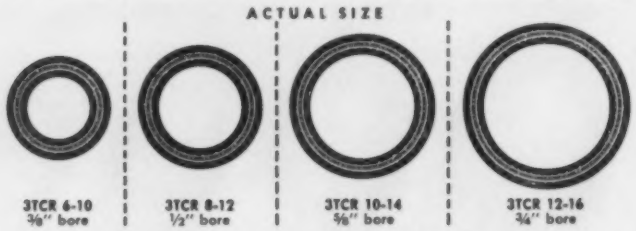
new

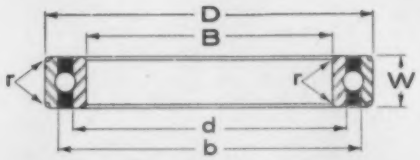
small bearings for big jobs

Thin-section **midget** T series precision ball bearings were designed primarily for instrument application, and to bring new, high standards of performance to their size range. Actual sales experience has shown a much wider range of application for these versatile bearings than heretofore anticipated.

These bearings feature: (1) light, one-piece retainer with true maximum ball complement — good for low torque values. (2) savings from 46% to 90% on space requirements, compared with conventional inch-series ball bearings of equivalent bore size. (3) no loading slot or other design compromise which might limit thrust capacity. (4) high ratio of load capacity to bearing volume. (5) rings and balls of stainless steel; retainer of pressure-molded fibre-reinforced phenolic. Made in precision and ultra-precision grades.

For complete information, get our catalog 59 . . . Write today.





*B bore ± .0002	*D o.d. + .0000 − .0004	W width + .0000 − .0050	†r radius	b outer land ± .001	d inner land ± .001	Balls no.	Balls size	‡L lbs.	§S lbs.
.3750	.6250	.15625	.010	.542	.457	16	1/16	77	110
.5000	.7500	.15625	.010	.672	.587	21	1/16	89	144
.6250	.8750	.15625	.010	.797	.712	24	1/16	94	165
.7500	1.0000	.15625	.010	.922	.8375	30	1/16	101	206

Dimensions are in inches. *Tolerances shown are for Precision Grade. Write for Ultra Precision Grade tolerances. †r is maximum fillet radius on shaft or housing that bearing will clear. ‡Radial load capacity at 500 rpm and 2500 hours average life. §Static non-Brinell load capacity.

split ballbearing
A DIVISION OF MPB, INC.
907 HIGHWAY FOUR, LEBANON, NEW HAMPSHIRE

READER TO EDITOR

Where Did You Get That Figure?

To the Editor:

In the May 9 issue you have an articile, entitled "Does Your New-product Idea Measure Up?" (p 59). About the middle of the second paragraph, (2nd col) you say, "At this rate, $a_6 = 12.89d$ or $1,891,169." Try as I may, I cannot discover where 12.89d came from.

—Dr T A Hunter
Manager, Analytical Sciences
The Cleveland Pneumatic Tool Co
Cleveland

• You are right, we should have included a brief explanation of where the 12.89d came from. The income, b_6, necessary to break even must cover all expenses to that point. Expenses are d (which is a_1 through a_5), plus a_6

$$b_6 = a_6 + d$$

If sales to breakeven point include 7.2% profit, then

$$d = 0.072\, b_6$$

$$b_6 = \frac{d}{0.072}$$

by substitution

$$a_6 + d = \frac{d}{0.072}$$

$$a_6 = d\left(\frac{1}{0.072} - 1\right)$$

$$a_6 = 12.89d$$

—Ed

Feet, Not Inches

To the Editor:

In your "For Your Information" item Apr 25, p 32 covering the Addyco Steel Strip, we would like to point out an error —$8.40 for a package of a dozen galvanized strips in 6-foot, not 6-inch lengths.

—Ashley R Tee, *Director*
Addy Products (Sales) Ltd
Southhampton, Eng

Wear Life of Rolling Surfaces

To the Editor:

It is rather interesting to watch people fall into fallacious mathematics. In the article on "Wear Life of Rolling Surfaces," May 9, p 46, equation 4 shows the load stress as

$$F = \frac{fK \cos \alpha}{1/\rho \quad 1/r}$$

The equation appears to be valid within certain limiting conditions. Then in equation 5, we have the statement, "If a flat-face follower is used instead of a roller follower, r goes to infinity in Eq (4) and the load becomes:

$$F = \rho f K \cos \alpha$$

As I recall, one thing that my mathematics teachers impressed upon me was that you cannot divide by zero and come

up with a result that has any meaning. Since Mr Myatt is a professor of mechanical engineering, we can only assume that there is a typographical error, since if the quantity r approaches infinity, then the value of F would become infinity also.

—W H Sayler
Specialty Sales Co

• You're quite right—it is a typographical error. A plus sign was omitted from the denominator between factors $1/\rho$ and $1/r$.—*Ed.*

To the Editor:

The article on "Wear Life of Rolling Surfaces" is very interesting and should be of considerable value in engineering design. Although the cast irons are well-established engineering materials, there is considerable concerning their properties still to be determined. Wear properties can be very often closely related to the microstructure in cast irons. Unfortunately, data on this was not included, and the Brinell hardnesses in some cases could cover some variety in structure.

However, this is probably more the result of an oversight on the part of the industry rather than the particular authors in this case. —Charles F Walton
Technical Director
Gray Iron Founders' Society Inc

Corrections:

In our May 23 issue, p 42, we incorrectly listed the address of General Electric Co's Instrument Div. It is located in West Lynn, Mass. Also, a design award citation was given to GE for a device to measure industrial liquids and gases, not just natural gases as stated.—Ed.

COMING EVENTS

JUNE

19-21 . . . . Alloy Casting Institute, Annual Meeting, The Homestead, Hot Springs, Va.

20-24 . . . . American Society for Engineering Education, 68th Annual Convention, Purdue Univ, Lafayette, Ind.

27-29 . . . . Institute of Radio Engineers, 4th National Convention on Military Electronics, Sheraton Park Hotel, Washington, DC.

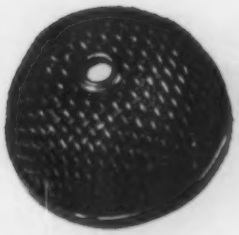
27-July 1 . . . . American Society for Testing Materials, 63rd Annual Meeting, Chalfonte-Haddon Hall Hotel, Atlantic City, NJ.

AUGUST

1-3 . . . . Institute of Radio Engineers, 4th Global Communications Symposium, Statler-Hilton Hotel, Washington, DC.

28-Sept 1 . . . . American Society of Mechanical Engineers, International Heat Transfer Conference, University of Colorado, Boulder, Colo.

Special
WIRE CLOTH
PARTS



save money

save time

no production problems

no quality problems

Newark is the place to come for your fabricated wire cloth parts. We can save you time and money. We weave our own wire cloth so you have no quality control problem. We take care of production scheduling . . . you have no idle manpower or idle machine time worries. We will give you a better part at a lower cost.

For more data on this phase of NEWARK Service, send for our Wire Cloth Parts Catalog. If you have an individual problem and would like to have us recommend the best way to insert the wire cloth piece send us tentative drawings and specifications. If you are ready to order, we'll be glad to quote.

NEWARK for ACCURACY

Newark
Wire Cloth
COMPANY
351 Verona Avenue, Newark 4, New Jersey

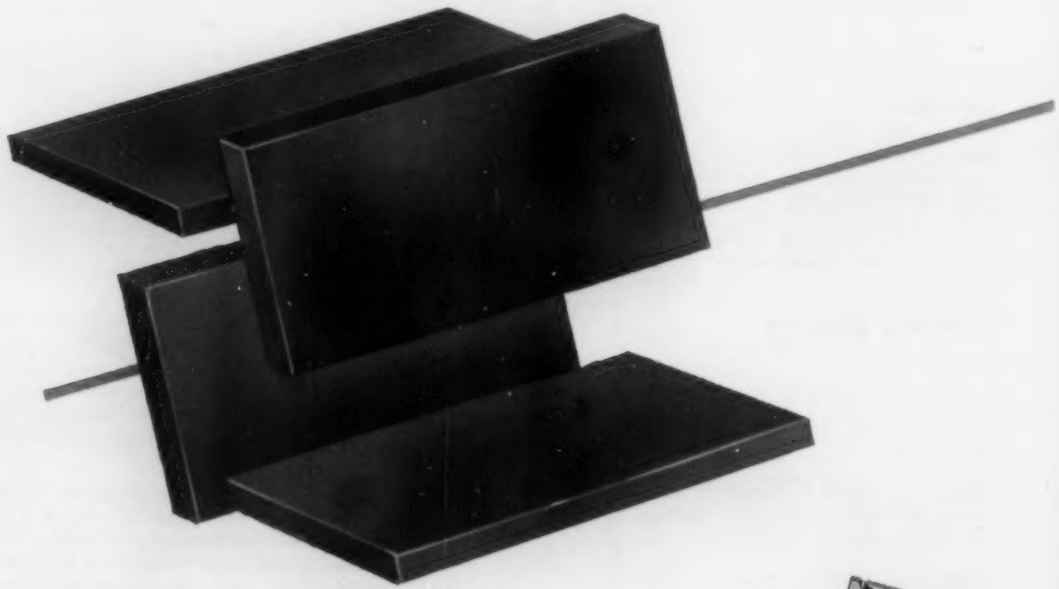
CIRCLE 29 ON READER SERVICE CARD

GRAPHITAR® VANES

(CARBON-GRAPHITE)

and long life of CONDE

This rotary positive displacement pump, engineered and produced by the Dri-Air Pump Department of the Conde Milking Machine Company, Inc., of Sherrill, N. Y., is designed to deliver clean, dry air or gas for high vacuum and low pressure applications in hospitals, dental offices, chemical or pharmaceutical plants, industrial processing systems and in metalworking plants. Thanks to vanes of GRAPHITAR, the CONDE Dri-Air Pump gives years of trouble-free, continuous operation at maximum recommended vacuum and speed . . . *without lubrication!* The GRAPHITAR pump vanes are self-lubricating and are seated by centrifugal force. Operating with a minimum of friction, they become increasingly efficient as the pump is used. In addition to their self-lubricating properties, the GRAPHITAR vanes are hard, light, non-sticking, non-warping and chemically inert. Perhaps these qualities can be utilized to advantage in your products.



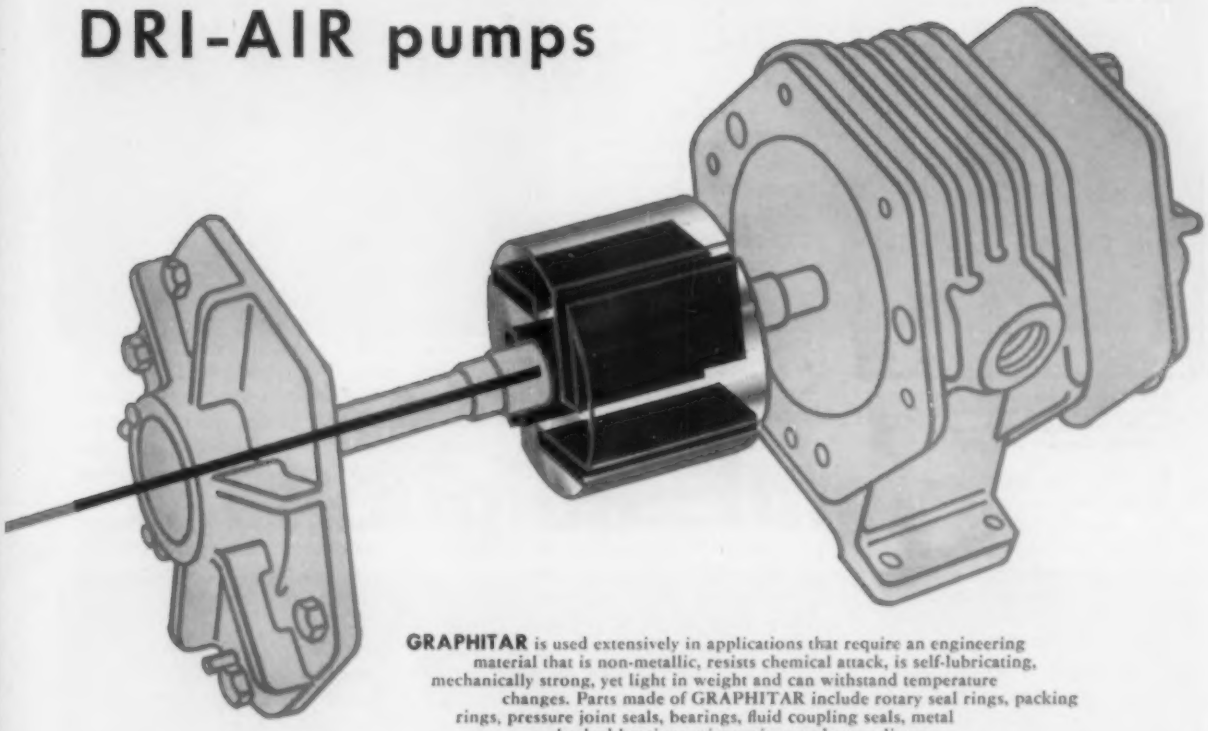
Bulletin #20 includes detailed design data along with properties, characteristics and typical applications of GRAPHITAR. Write for your free copy. If you have questions concerning the incorporation of GRAPHITAR parts in your products, our engineers will be glad to assist you.

THE UNITED STATES

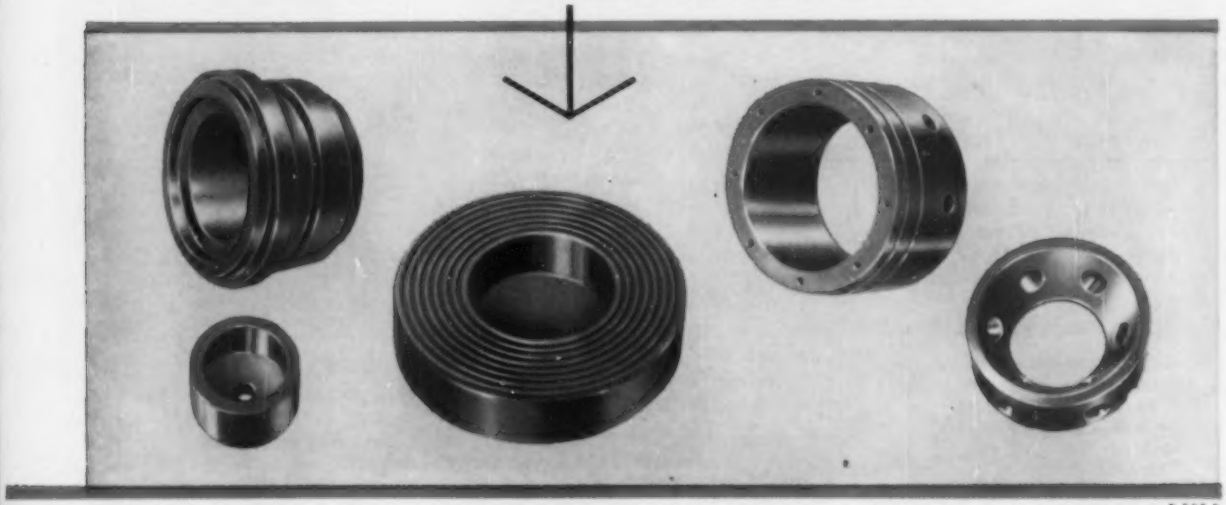
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

help insure efficiency

DRI-AIR pumps



GRAPHITAR is used extensively in applications that require an engineering material that is non-metallic, resists chemical attack, is self-lubricating, mechanically strong, yet light in weight and can withstand temperature changes. Parts made of GRAPHITAR include rotary seal rings, packing rings, pressure joint seals, bearings, fluid coupling seals, metal backed bearings, piston rings and pump liners.

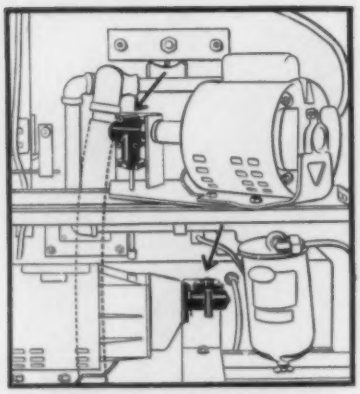


R-285-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

ANGLgear® simplifies another 90° drive problem



Drawing based on photograph of Unicorn film cleaner shows location of Model R-330-2 ANGLgear units used respectively to transmit power to cleaning rollers and drive rollers.

In designing an automatic cleaner for motion picture film and magnetic tape, Unicorn Division of Computer Measurements Co., Sylmar, Calif., selected ANGLgear instead of open bevel gear drives for the following reasons:

(1) Lower initial cost and faster assembly — because ANGLgear eliminates design and installation of individual shafts, gears and bearings; (2) greater compactness—helps cut bulk; (3) more rigid drive—no possibility of gears getting out of mesh; (4) quieter operation.

If you have a design requirement for 90° power takeoff, investigate ANGLgear, the standardized right-angle drive. Completely enclosed, permanently lubricated, and featuring universal mounting, it is easily incorporated in your power transmission systems and requires virtually no maintenance.

You can specify ANGLgear from stock in ⅓, 1, 2¼ and 5 hp ratings, with choice of 1:1 or 2:1 gearing and 2 or 3-way shafting. See Sweet's Product DesignFile or contact our local distributor.

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Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

WHY DON'T THEY R&D..?

The following problems have been encountered by the Armed Forces. If you think you have a solution—or if you wish additional information—get in touch with National Inventors Council, US Department of Commerce, Washington 25, DC.

. . . improved techniques for airdropping equipment and cargo safely and reliably. A great variety of materials, from a crate of supplies to a complete vehicle, are commonly dropped from aircraft and range in weight from 2000 to 20,000 pounds. The problem of reliable airdrops can be attacked from two sides: a decelerating device that slows the rate of descent to a velocity of 50 to 25 ft per sec or less; and an energy dissipator that absorbs large impact shocks.

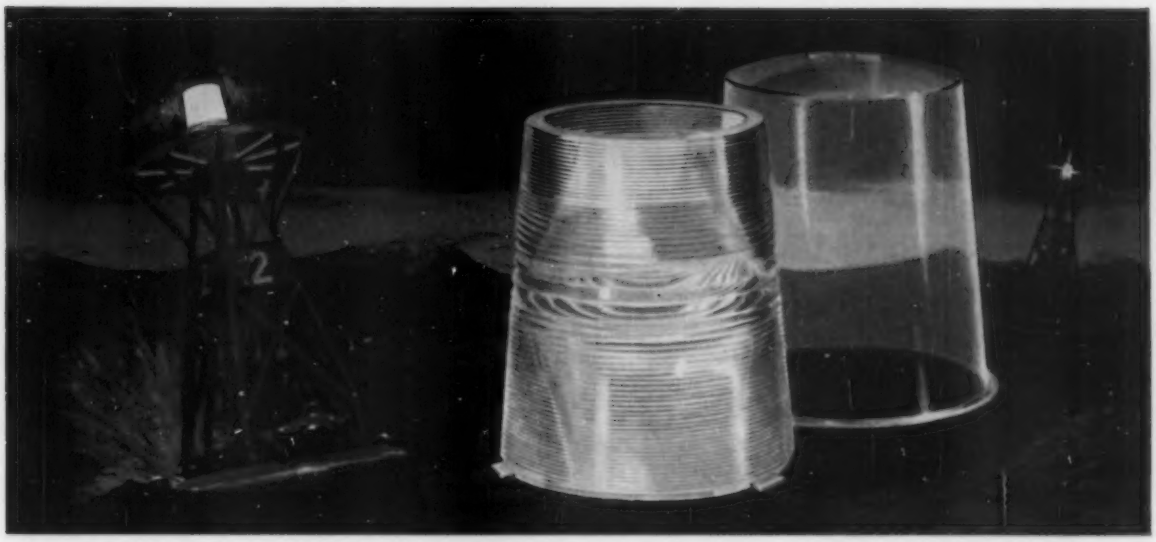
A variety of parachutes have been tried for reducing rate of descent to a low constant velocity. Parachutes have several disadvantages: They are heavy, bulky, are easily fouled, and do not provide the necessary aerodynamic drag except when very large. Further, if there are high winds at the surface, there is the hazard of dragging the equipment across the ground unless wind is spilled from the parachute immediately upon impact. A system of collapsible, rotating blades has been tried for small loads. Made of fiberglass, the blades slow the descent by whirling in a manner similar to the autorotation of a helicopter. Perhaps a similar scheme (with telescoping blades for more compact storage) would be practical for large loads.

Several methods have also been tried for absorbing impact energy. Present airdrop platforms dissipate energy through a multitude of felt pads. Airfilled, rubber cushions have also been tried and are now under test. The needed device should be not only an efficient energy absorber but adjustable to withstand decelerating forces over a range of 25 to 150 lb per sq in. Foamed plastics have been developed for this purpose and show some promise. They crush at essentially constant stress to 75% or more of their original thickness and have little, if any, resilience. They can be foamed at ambient temperatures ranging from 40 to 125 F and are producible in a range of densities. Still needed, however, is simpler foaming equipment, lower cost materials, higher energy dissipation per unit weight, and the capability of being foamed at lower ambient temperatures.

. . . improved seal for the neck of a full-pressure flight suit. At present, the ring seal at the neck is made in two parts: one half mounted on the suit and the other half mounted on the helmet. The ring seal prevents pressure escaping from the suit and acts as a bearing to permit side-to-side head movement. For an effective seal, both halves are solid rings and must therefore be large enough to slip over the pilot's head. But these rings interfere with up and down head movement and block downward vision.

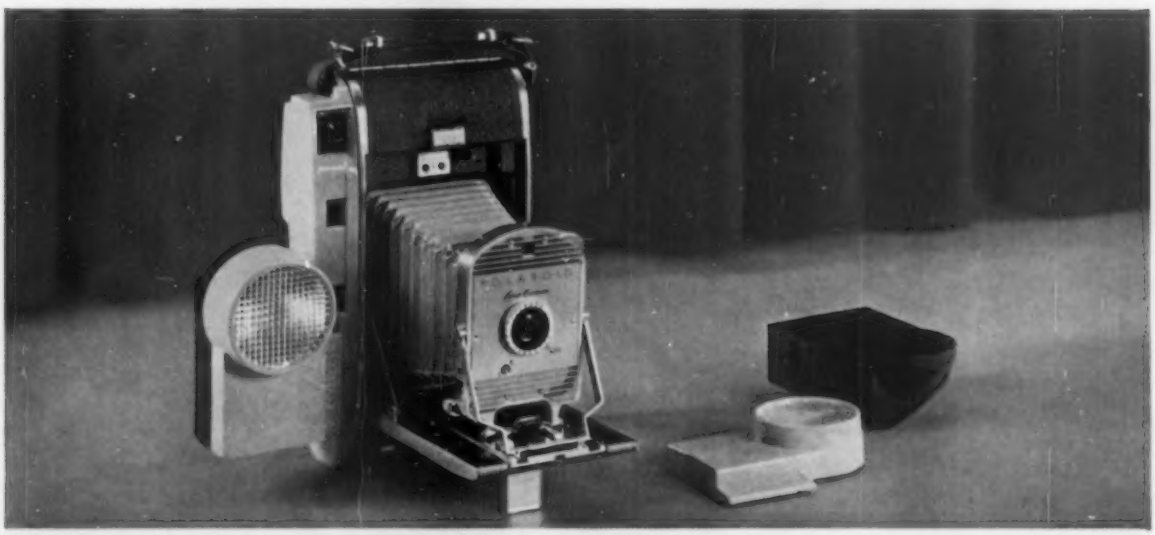
If the rings were hinged as in a bracelet, the inside diameter could be decreased to approximately the size of the pilot's neck. This would give improved vision and the helmet could be put on without slipping it over the head. Further, the radius of the ring would be decreased and, with decreased bearing torque, the pilot would be able to rotate his head more freely.

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.



Handsome and Hardworking

Plexiglas...Implex



Flashing lights at sea shine brightly through large lenses and covers molded of PLEXIGLAS® acrylic plastic. The PLEXIGLAS parts are used in navigation lights for the U. S. Coast Guard, at a fraction of the cost and weight of cut glass lenses. Precision molding of the lens pattern gives the PLEXIGLAS lens maximum efficiency in light control, and the material resists weather, breakage and salt water.

Winking lights at home are revolutionizing indoor photography by making indoor pictures without flashbulbs possible, with the new wink-light attachment shown above. Tough IMPLEX®, the high impact acrylic, gives handsome appearance and rugged durability to the housing. PLEXIGLAS is used for the lens.

We will be glad to help *you* use these Rohm & Haas acrylic molding materials—to your advantage.

Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

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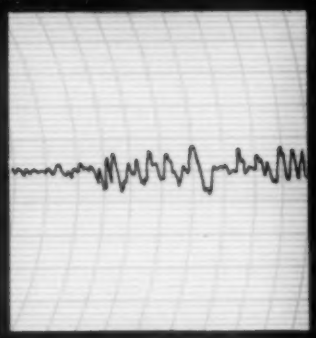
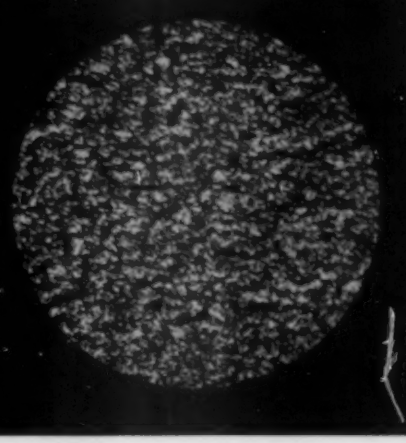
THESE SURFACE TRACES PROVE

when you use Formbrite, Anaconda's superfine-

STANDARD DRAWING BRASS
(grain size, .045 mm) – after 40% elongation

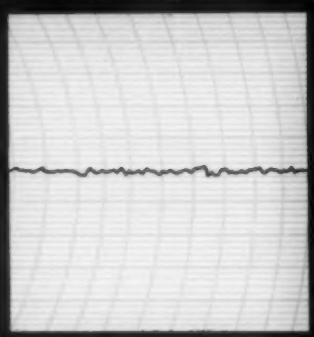


ENLARGED SURFACE TRACE showing the roughness that causes "orange peel" effect in the working of standard drawing brass. Smoothing such mountains down to the valleys takes a lot of cutting—cost of polishing compounds runs high—production is low—bottlenecks hamstring operations.

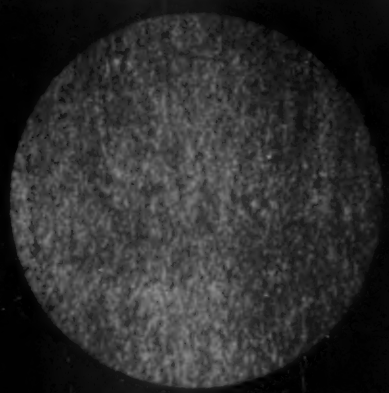


THE SURFACE of the stretched standard drawing brass sample looks like this when seen in oblique illumination and magnified 20x. For small deep-drawn products, it might take up to five polishing wheels to finish a surface with roughness of this order—even at low machine speeds.

FORMBRITE DRAWING BRASS
(grain size, .005 mm) – after 40% elongation



ENLARGED SURFACE TRACE showing Formbrite's smoothness even after deformation, the test of polishing characteristics of a drawing brass. Little hills like these are easy to level. The trace explains why polishing savings reported by Formbrite users are usually 40% to 50%.



WHEN SEEN IN OBLIQUE ILLUMINATION and magnified 20x under the microscope, the stretched Formbrite surface looks like this. Even in such deep-drawn products as pen caps, only a light cut and a color buff are needed for a jewelers' finish—often a color buff alone does the job.

DESPITE its superiority, Formbrite costs no more than standard drawing brass. It is produced in the following brass alloys: Yellow Brass, Cartridge Brass, Gilding, Commercial Bronze, Red Brass, and Low Brass. The Formbrite process is also applied to brass wire alloys for cold-heading and upsetting purposes—for a stronger, springier, more abrasion-resistant product.

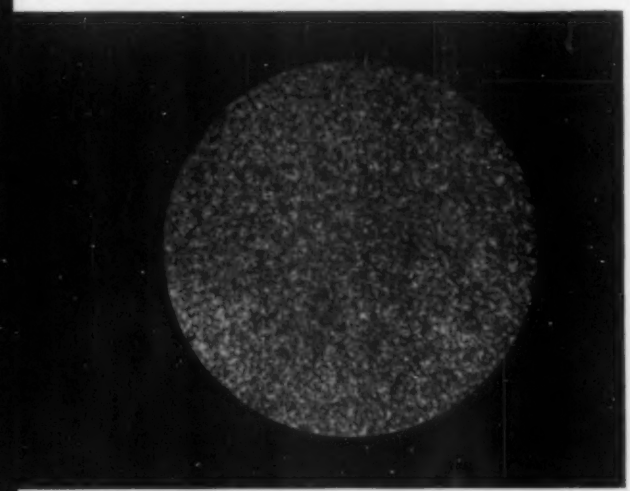
Get the full details from your American Brass representative, or write: The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

6049

YOU CAN CUT POLISHING COSTS

grain drawing brass

THIS IS THE MICROSTRUCTURE of the standard drawing brass sample at 75x magnification. The coarse grain structure is typical of the drawing brass that has for decades been used for stamped or drawn brass products. It is the basic reason that polishing costs have run high.



THIS IS THE MICROSTRUCTURE of the Formbrite sample, magnified 75x. The uniform, superfine-grain structure, produced by special procedures of rolling and annealing, explains the relatively smooth surface trace of the stretched Formbrite sample, at the left.

FORMBRITE®

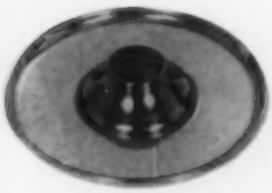
Superfine-grain drawing brass

A PRODUCT OF

ANACONDA®

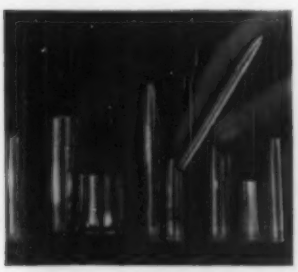
MADE BY THE AMERICAN BRASS COMPANY

The outstanding feature of Formbrite is easy polishing. But there's something else you should know about it. Formbrite is stronger, harder, springier, and more scratch resistant than the usual drawing brasses. Yet it retains remarkable ductility for forming, stamping, drawing, and embossing. In many instances, these qualities have made it possible to use thinner gage metal.



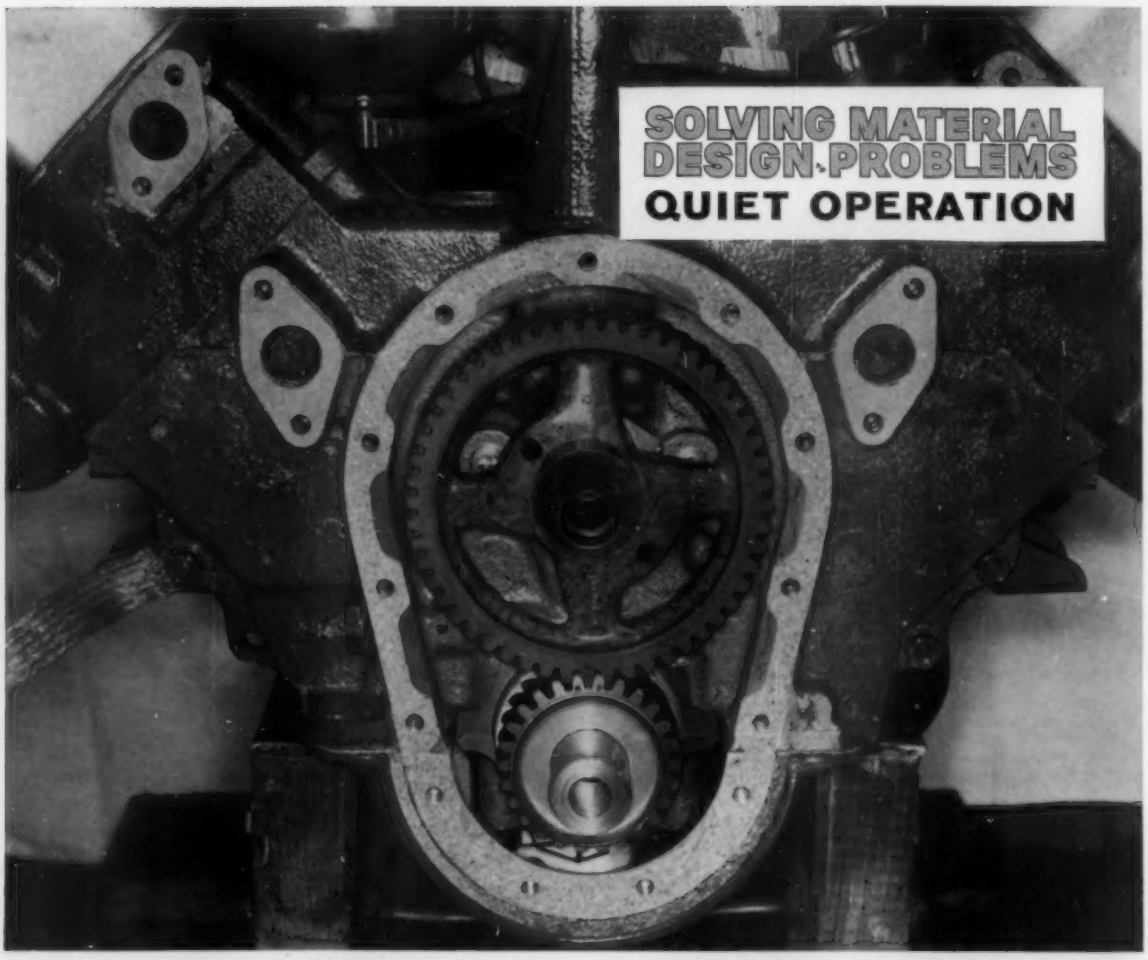
The maker of this tray, after switching from ordinary drawing brass to Formbrite, found he had achieved a cost reduction of 25% in the cutting operation and 42% in the finish buff—and a healthy boost in production rates.

These fishing lures, first made from ordinary yellow brass, are polished for plating by tumbling. After the switch to Formbrite, manufacturer found he had cut his polishing costs 40%. Small-size formed, drawn, or upset parts made of Formbrite often can be satisfactorily finished by the relatively low cost conventional tumbling methods.



A jewelers' finish on these deep-drawn products meant the use of five polishing heads, with regular drawing brass. With Formbrite, manufacturer uses two polishing heads for a light cut, another for a simple color buff, and runs machines faster. Savings run up to 40%.

When this gage case was made of Formbrite, the instrument manufacturer found he could drop the cutting operation and get a "mirror finish" with a light buff. The saving in finishing cost was 40%.



Timing gears made of CDF Celoron will not pick up and amplify sound due to Celoron's naturally low tone frequency. Tests show that Celoron gears reduce noise by up to 50% compared to all-metal gear sets!

Made of quality controlled, fabric reinforced phenolic resin, Celoron® high-impact gears are constantly replacing metal in critical areas ranging from earth-moving machinery to compact cars to movie projectors.

Celoron molded materials are only one family of products from industry's largest selection of non-metallic structural and electrical materials . . . including thermosetting laminates, vulcanized fibre, silicone rubber, and mica.

This wide choice gives you every assurance of meeting your exact quality and cost needs in plastic material. Refer to Sweets PD file or write to us for the latest Celoron catalog.

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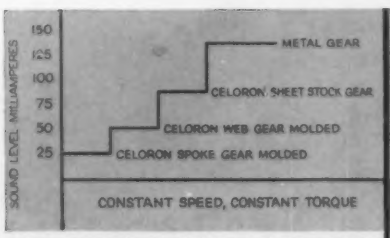
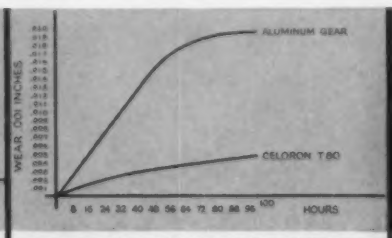
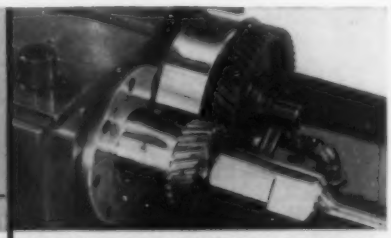


Low sound level of Celoron is shown by this graph which compares metal to the different types of Celoron gears.



Long wearing characteristics of Celoron gears are here contrasted to the shorter life spans of metal-made gears.



Quality control of Celoron gears is assured by special testing machines such as this in CDF laboratories.

stainless steel

No other metal has the strength, beauty and versatile qualities that serve you so well today and promise so much for tomorrow.

There is nothing like stainless steel for HOMES AND HOME PRODUCTS

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shape up OEM designs—profitably!

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ORCO CAPACITY offers the facilities of four modern plants. These include design, building, and maintenance of precision molds and dies . . . permanent bonding-to-metal . . . compression and transfer molding . . . extruding of all shapes, sizes, and types . . . complete laboratory facilities . . . statistical quality control . . . coordinated production control.

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Maybe it's a basic defrosting problem in industrial refrigeration . . . or perhaps it involves the vital protection of aircraft from the icy upper atmospheres.

For these and scores of in-between applications, Safeway provides a *controlled heat* product, regardless of environmental temperatures. And people who know refrigeration depend on Safeway Heat Elements as a completely reliable and economical solution to defrosting problems in the commercial and industrial field.

Safeway's modern manufacturing facilities are devoted *exclusively* to the design, engineering and application of *controlled heat* for industry. Among the wide variety of Safeway heating blankets, woven and molded heating elements are:

- **heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft**
- **de-icing units for airfoil surfaces**
- **heating elements for all types of ground support equipment**
- **defrosting units for industrial and commercial refrigeration**
- **heating blankets for honeycomb and metal-to-metal bonding**

For your copy of a fact-filled folder, please write:

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems carefully, and—without any obligation—submit an appropriate recommendation.

Safeway HEAT ELEMENTS INC.

Middlefield Street • Middletown, Connecticut

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Large, small or in between...we make it

Size is no problem in our fabrication of Synthane laminated plastics. Whether the part fits into your palm or onto the head of a pin, or towers over you, we believe we can handle it.

Why? Because we make the material and can control it to suit the job. Our variety of machines and tools, many of them special, permit the widest freedom in the choice of a machining approach. Our skilled people have rolled up over 30 years of experience in doing the difficult and impossible. So, large, small or medium in size, let us take the production worries of your part off your mind.

Call your Synthane representative for a quotation or write Synthane Corp., 4 River Road, Oaks, Pa.

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CORPORATION OAKS, PENNA.

Sheets • Rods • Tubes • Fabricated Parts
Molded-laminated • Molded-macerated

You furnish the print—we'll furnish the part

PRODUCT ENGINEERING HORIZONS

June 13, 1960

The Better Haircut

What makes the professional? Webster says of the word: "of or pertaining to a profession, especially a learned or skilled profession . . . conforming to the technical or ethical standards of a profession or occupation regarded as such . . . engaging for livelihood or gain in an activity pursued, usually or often, for noncommercial satisfactions by amateurs. . . ."

What, then, is a professional engineer? We must assume from the first (hence commonest) definition that there are professions which are not "skilled or learned" as engineering is, so must go on for further differentiation. Next comes the "conforming to . . . standards," which again draws no fine line, because neither set of standards has been rigidly set. Lastly, there's the crass statement regarding pay, which we've learned (particularly in sports) is no way to distinguish between amateur and professional.

These reflections are generated by a recent newspaper report that dance teachers and frog dealers, among others, are seeking state licenses. Their objective? Just like ours: to obtain prestige and to reduce competition by becoming known as professionals.

Wrong guess, ladies and gentlemen! Becoming known and licensed as a "professional" doesn't necessarily bring prestige, exclusiveness, recognition, or even higher income. Remember that barbers and barkeeps, as well as doctors, dentists and beauty-shop operators, are all state-licensed, too. Some of these professions have prestige, some do not. There are even professions on the wrong side of the law which have some distinction and recognition, if not prestige (although amateurs have been giving them some rough competition of late years).

There's an old story about Sir Henry Irving, famous actor of the last century, that may illustrate my point. As he was leaving his London theatre one night, he was accosted by a young lady, who burst out with: "Sir Henry, please pardon my temerity in addressing you, but I just cannot resist this opportunity to express my deep respect and admiration for your artistry!"

"Thank you, my dear," said Sir Henry, "and are you of the theatre?"

"Oh, no, sir! I'm a prostitute," admitted the young lady.

Said Sir Henry: "Will you join me in my carriage, Miss? I'd like to talk further with a representative of the other ancient and honorable profession that has been ruined by amateurs!"

Sober-minded engineers have made the point that engineering will have difficulty attaining professional status because most engineers are employees rather than entrepreneurs. This is a good point, but again not an entirely valid one. Some of the greatest advances in medicine were made by doctors employed in laboratories, some of the greatest advances in law were made by corporation lawyers or by judges—who are employees of government. And some of the great advances in both fields have been made by amateurs.

So professional status isn't determined, apparently, by technical or ethical standards, livelihood or lack of it, by licensing or learning, but rather by skill, enthusiasm, and, most of all, by humanity.

Doctors and lawyers deal with people in trouble, and help them. Isn't this the source of their public recognition, of their status? Doesn't the engineer who solves a personal problem for people attain prestige and professional recognition too? Didn't the orbiting of Sputnik I, and the recognition by people that their very lives are now a function of engineering, give our profession more status than all of our own efforts?

Perhaps the secret of professional success is in engineering for humanity, not in a better haircut.

K. Langeman

(Advertisement)

the LEAD newsletter

Vol. 2 No. 2

Lead Antennas

During the Korean War, Helicopter design engineers were stumped with the problem of finding space for the radio antennas for rescue helicopters. A stretched wire antenna seemed to run afoul of something no matter where it was placed on the craft. Lead tape saved the day. Adhesive backed, the tape could be stuck to any convenient member of the frame. A single bolt through the tape and its supporting surface (insulated from metal parts, of course) clamps the electrical lug in place to complete the antenna.

The call for help that brought this Bell Rescue Helicopter was received with a lead tape antenna.

Rotor Blade Test

Nor is lead tape confined to flying helicopters. Kaman Aircraft Corporation uses it to find the balance point of rotor blades at various pitch angles. Thin enough to not change critical contours, the tape nonetheless packs enough heft to be handy in prototype testing. Though the tape is replaced by metal structural members before any aircraft is used or sold, it does save time in making on-the-spot quick weight changes in the exact increments required.

Lead Masking Tape

Turco Products' new chemical milling process employs powerful etchants to remove the metal of the complex shapes it produces. Since it is so fast and easy to apply, lead tape is a time-saver here, too. It can be trimmed to a clean, sharp outline. It resists the etching solution. It has become a handy adjunct to other masking materials—especially to cover pinholes and mask edges.

Oilless Bearing for −328° to +536°F. Operation

Bearings that require no oil, grease, graphite, or any other applied lubrication have long been a designer's dream. This dream is now a reality. Developed by the British and called DU, this bearing material is available in the U.S. from the United States Gasket Company.

DU combines the well-known excellent bearing properties of lead with the ultra-low coefficient of friction of TFE fluorocarbon plastics. A mixture of lead and TFE powders is impregnated in a fine porous bronze skeleton which provides high heat conductivity to keep the bearings cool. Tin-plated steel backs up this combination. The result is a bearing material with low friction characteristics, very low wear, and high compressive strength. DU bearings endure intermittent operation at 40,000 psi compressive load where ball races had previously failed.

And that's not all. DU bearings have operated successfully at −328°F. and as high as 536°F. Quick, wide changes in temperature cause no difficulty either. Although new, DU has already found many applications. Among them: jet engine air intake vane bearings, landing gear and control rod bearings, and in automobiles in the electric starter motor, generator, steering column and other locations.

Lubrication for 1250°F. Service Developed at NASA

An effective lubricating system for use up to 1250°F. ambient temperatures has been developed at the NASA Lewis Research Center in Cleveland, Ohio. A bonded lead oxide film was the answer here. Applied in the manner of porcelain enamels to stainless steel (type 440C), the film consists of PbO, 5% SiO_2 and about 5% Fe_2O_3 absorbed from the steel during firing.

Compared to commercial resin-bonded type molybdenum disulphide coatings, the PbO films provided superior wear and lower friction coefficients above 600°F. These coatings operate best at high temperatures and high sliding velocities. In fact, at sliding velocities from 2,400 to 10,000 ft. per min. the friction coefficients were practically constant ($F = 0.05$ to 0.08) at all temperatures studied.

As ambient temperatures are increased, endurance life is found to increase and approaches a maximum at about 1,000°F, then decreases slightly at 1,250°F. Although other lubricants are superior below 600°F, these coatings have satisfactory properties in the low temperature range so that they can be used in operations which start at low temperatures before coming to the higher operating temperatures.

Permanent Color for Lightweight Building Block

An important new addition has been put in the architect's bag of tricks by Zonolite Company—*glazed* lightweight aggregate building blocks. These lightweight blocks are permanently waterproof, permanently colorful. And since both interior and exterior walls are glazed, they are both finished and ready for use without further protection or decorating.

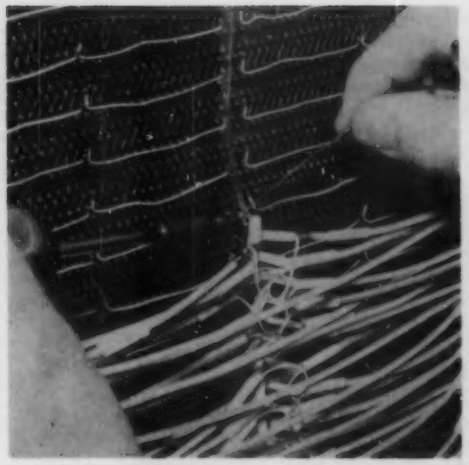
The blocks are a reality because of Lead's ability to promote glaze-body reactions, control viscosity, and produce a low surface tension, all at low firing temperatures. A wide variety of textures can be produced from rough and matte to smooth and glossy, even over the rough texture of the block itself.

If you would like information or technical assistance on new lead developments and applications, write to: Office of Technical Information, Lead Industries Association, 292 Madison Avenue, New York 17, N.Y. 2029

LOOK AHEAD WITH LEAD

PRODUCT ENGINEERING

SPECIAL REPORT



how to choose the right

SOLDER FLUX

The old classifications of "corrosive" and "noncorrosive" fluxes are no longer adequate for today's soldering needs. Here's an up-to-date flux selection guide, based on chemical origin, and covering all the significant types.

HOWARD H MANKO, *associate metallurgical engineer*
Product Development Laboratory IBM, Poughkeepsie, NY

About the Author

Howard Manko, a chemical engineer as well as a metallurgist, has found both disciplines valuable in his work as a specialist in metal-joining problems at IBM since 1956. He earned his BS-Ch E at the Israel Institute of Technology, Haifa, in 1952. One more year's schooling earned him the much-coveted Professional Engineering Diploma, roughly the Israeli equivalent of New York State's PE license. "In Israel," says Manko, "the qualifying exam comes immediately after the added year's study, with five years' experience then required before you can consult—just the reverse of New York State's procedure." Of the two, Manko much prefers the Israeli system: "You don't forget so much before the exam!" His metallurgical training came at New York University, where he received his MS degree in 1960.

Accurate and reliable soldering has become an industrial imperative: New structural metals need joining, electrical assemblies are more compact, automatic manufacturing is on the upswing, repair work is becoming impractical, electronic components are more heat-sensitive.

These trends are forcing soldering to change from a hit-or-miss art to an engineering science. Proper selection and usage of soldering fluxes are vital to this change. Here, the handbooks are incomplete or archaic. To fill the gap has required examining, testing and classifying all the industrially important flux types. Result is the comparison given here, which will simplify flux selection. With it is much-needed information on the properties of a good flux, how fluxes work, how to select and specify them—along with practical examples.

Does a soldered joint have to be designed? -Yes, very definitely. You can't just pick two compatible metals and specify that they be soldered. Such an approach ignores the flux—the single most important factor in the complex process of soldering. Choose a flux wisely, and you'll have a reliable joint. Pick the wrong one, and rejects will mount. What follows is a guide to the right decision.

Flux means, simply, flow; but in soldering, the flux has functions other than just aiding flow (see "Mechanism" on the next page). While it does not enter into the bond-formation itself—in this respect it is analogous to a catalyst in a chemical reaction—the flux does

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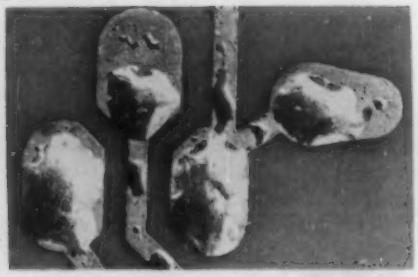

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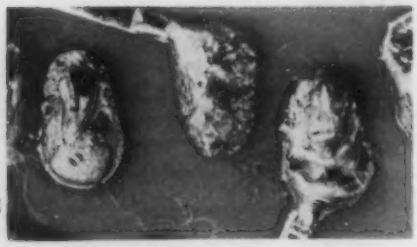

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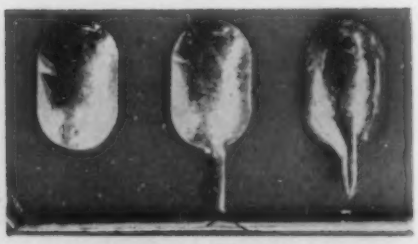

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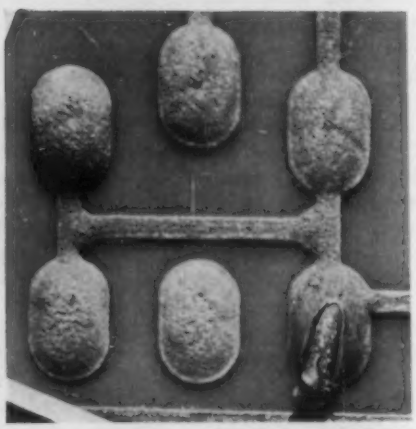

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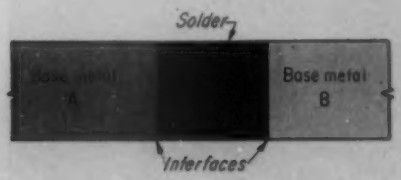
Which soldering is good and which bad on these printed circuit junction points? (1) Unsatisfactory, dewetted joints; surface energies are working against spreading, pulling the solder into balls. (2) Unsatisfactory, cold joints; solder was jiggled during solidification, causing frosty surface and internal fractures. (3) A good joint; solder is smooth, bright and well feathered. (4) Unsatisfactory, corroded joint; still-active flux residues were not washed off after soldering.

MECHANISM OF

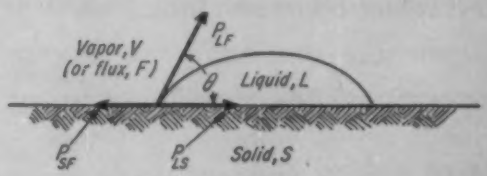
When two metal parts are joined by solder, the metallic continuity established is the result of two interfaces, where the solder is bonded to each of the metal parts. The sketch below shows the metal continuity from base-metal A to base-metal *B*. Note that the solder serves both as the bond-maker and as a link in the metallic continuity.



A closer examination of the bond-making function leads to a better understanding of the soldering process. For this, a single interface will suffice—the basic solder/flux/base-metal system.

Under normal conditions, both base metal and fusible solder alloy have a surface layer of tarnish, which interferes with formation of the interface. Removing these films is a primary function of a flux. Once these oxides and other products of environmental attack have been removed, the exposed metallic surfaces are ready for bonding.

At soldering temperatures, the base metal is solid, the fusible solder alloy is liquid, and the flux is usually a liquid. Consider a drop of liquid solder (sketch below)



resting on a flat, horizontal, metal surface in an inert atmosphere where no oxidation occurs. This is a three-component system of solid S, liquid L and vapor V. In actual soldering, the liquid-flux phase replaces the vapor phase.

affect the rate and degree of completion of the soldering process. With clean metal surfaces in the right atmosphere, a good solder bond is obtained without flux. We use fluxes because such ideal conditions in industrial applications are hard to achieve, time-consuming, and costly.

PROPERTIES OF A GOOD FLUX

To do its job well, a flux must perform two major functions:

- Provide tarnish-free surfaces, and keep them clean throughout the soldering operation.
- Influence the surface-tension equilibrium in the direction of solder spreading.

How well the flux performs is measured by the following:

Chemical activity. All products of environmental attack —called tarnish-films here—must be removed before a

SOLDER-JOINT FORMATION

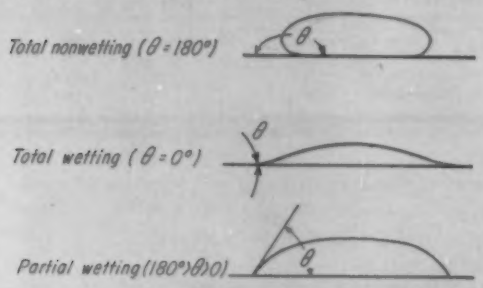
At the point of total thermodynamic equilibrium the system will have a border line at which all three phases—solid, liquid, and flux—meet. In a plane perpendicular to this border, the three phases meet at a certain angle to each other. This angle, θ, formed between the liquid and the solid, is called the dihedral angle.

The three forces are: the surface tension between the liquid and flux phase, P_{LF}, acting at a tangent to the liquid curvature; the interfacial tension, P_{LS}, and the surface tension between solid and flux, P_{SF}—both acting along the solid surface, but in opposite directions. The balance of forces along the surface is called the wetting equation:

$$P_{SF} = P_{LS} + P_{LF} \cos \theta$$

Whether or not the drop of solder wets the fluxed surface depends on the particular combination of materials and their interacting surface tensions. These quantities are not usually known, but the dihedral angle θ is a good visual clue to wetting, because it is a constant for any set of three phases. If the droplet retains its shape and refuses to spread, $\theta = 180°$; the coalescing forces exceed the thinning forces and the condition is totally nonwetting (see sketches below). When total wetting occurs, the spreading forces are dominant and the drop loses shape, becoming a film; then $\theta = 0°$.

Partial wetting, in between these extremes, is the usual case, inasmuch as the system freezes before complete equilibrium is reached. But how much partial wetting is enough? Experience has shown that inspection of the dihedral angle can give the answer. Three ranges for θ between 0° and 180° are important:



$\theta > 90°$ indicates a condition termed "dewet." The solder has frozen in the process of dewetting the surface to be soldered; that is, the driving force was in the direction of nonwetting. The rate of dewetting is a direct function of the dihedral angle when it exceeds 90°.

$90° > \theta > M$ indicates marginal wetting. Usually $M = 75°$ or less; M is the dividing line between good and marginal wetting. Unless special conditions exist, this type of wetting is not acceptable.

$\theta < M$ indicates good wetting. $M = 75°$. If extremely high quality is required, M can be taken as less than 75°. For quality-control purposes, M should be clearly stated as a criterion for good wetting and sound solder joints.

How the Bond Is Made

Consider a base-metal surface that has just been wet by a liquid solder, and solder solidified before or after chemical equilibrium is established. The same type of surface energies that promoted the wetting of the metal by the solder are now making the bond. These energies came from the unsaturated bonds of the surface atoms, which have less than the average number of nearest neighbors surrounding them. After the solder wets the solid metal, the two metals exchange surface energies, resulting in a mutual saturation of the adjacent surface bonds. The interface thus formed has great strength and stability because these energies are on an atomic level.

While the liquid solder is wetting the solid surface at an elevated temperature, there is some mutual diffusion at the interface due to the thermal activation. This layer of solid solution will contain the intermetallic compounds if the metal is one that will react with the solder. These intermetallic compounds are not vital to the bond formation, but lack the ductility of the parent metals. This can cause embrittlement of the interface.

In summary, the soldering mechanism includes these three steps:

1. Flux removes the tarnish films from the metal surfaces.
2. Flux changes the surface-energy balance, thus promoting solder wetting.
3. Solder wets the metal surfaces, forming an atomic interface that bonds the two together.

good solder joint can be made. Unlike grease, they cannot be removed with conventional solvents. The flux must therefore contain chemicals that will react with such films (usually oxides) to make compounds soluble in the flux and/or its vehicle. This action removes the tarnish film, leaving the surface exposed for bonding.

Thermal stability. Inasmuch as the flux must form a protective coating on the cleaned metal surfaces at soldering temperature, it must be able to withstand these temperatures without evaporating or breaking down. The stability must apply to either the flux or its solvent vehicle. The vehicle can have a boiling point below soldering temperature provided the flux itself is heat-stable. For example, a water vehicle tends to sputter, alcohols are flammable, etc. One good all-around vehicle, recently recommended by Tin Research Institute, is polyethylene glycol. Its advantages include high boiling point, heat stability, and water solubility.

Wetting power. The vapor phase on the metal surface must be displaced by the flux before soldering can take place. This wetting action involves a balance of surface energies at the metal solder-flux interface (see "Mechanism of Solder-joint Formation"), and so is not determined by the flux alone. A flux with maximum wetting power can be selected, however, for a given metal-solder combination. A word of caution here: fluxing is not a substitute for precleaning. Most fluxes are rendered useless by insoluble layers of dirt on the workpiece. A thorough degreasing contributes greatly to efficient fluxing and proper soldering.

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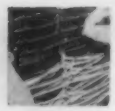


Table I – Comparison of Flux Materials

(in order of decreasing chemical activity)

	Classification and Type	Typical Fluxes	Vehicle	Use for These Joints	Temperature Stability
INORGANIC	Acids	Hydrochloric, hydrofluoric, orthophosphoric	Water, petrolatum paste	Structural	Good
	Salts	Zinc chloride, ammonium chloride, tin chloride	Water, petrolatum paste, polyethylene glycol	Structural	Excellent
	Gases	Hydrogen, forming gas, dry HCl	None	Electrical	Excellent
ORGANIC (Nonrosin Base)	Acids	Lactic, oleic, stearic, glutamic, phthalic	Water, organic solvents, petrolatum paste, polyethylene glycol	Structural, electrical	Fairly good
	Halogens	Aniline hydrochloride, glutamic hydrochloride, bromide derivatives of palmitic acid, hydrazine hydrochloride (or hydrobromide)	Same as acids	Structural, electrical	Fairly good
	Amines & amides	Urea, ethylene diamine	Water, organic solvents, petrolatum paste, polyethylene glycol	Structural, electrical	Fair
ORGANIC (Rosin Base)	Activated	Water-white rosin, with activators	Isopropyl alcohol, organic solvents, polyethylene glycol	Electrical	Poor
	Water white	Water-white rosin only	Same as activated	Electrical	Poor

Spreading activity. A flux that will decrease the contact angle between molten solder and base metal surface will promote solder spreading. Affinity of the flux for metal is also important. It should be lower than the solder affinity for metal, so that the flux will be easily displaced by molten solder. Of the two spreading effects, the flux's influence on contact angle is by far the more significant. This angle is a measure of good fluxing.

A fifth, though minor, characteristic of some inorganic fluxes that needs mentioning is electrochemical activity. In some cases, particularly with zinc chloride and ammonium chloride fluxes on copper, the flux will deposit solder ions on the metal surface by replacement–thus aiding the joining process. Here, some tin in the solder goes into the fused salt flux as tin ions. These then travel to the copper surface and deposit there by replacement of copper. The effect is one of pretinning; this speeds the spread of solder, since solder wets itself faster than most base metals.

INDUSTRIAL REQUIREMENTS

To make soldering an economical connecting method, fluxes must meet some additional practical requirements. A summary of these added points will help you determine whether a flux is of industrial value or merely academic interest. Which of these is most important varies from job to job.

Short soldering time is essential, particularly in a high-speed automatic set-up (such as the one shown on the cover of this issue of PRODUCT ENGINEERING) and in electronics, where assemblies are heat-sensitive. Consequently, a well-selected flux should rapidly affect the solder/base-metal system—allowing a maximum number of joints to be made per unit of time.

Soldering temperature, besides melting the solder, should be high enough to energize the flux into its cleaning function. Too high temperatures should be avoided, however, since organic constituents in the flux may become inactive if overheated. (An example: copper-cleaning ability of rosin-type fluxes is sharply reduced when they are heated rapidly to 600 F and kept there.) The "activated" rosin fluxes, however, require high heat to decompose and vaporize the cleaning agent, so that all residues are safe. A good general rule: Keep the soldering temperature 100 F above melting point of the system.

Tarnish Removal	Corrosiveness	Post-solder Cleaning Methods
Very good	High	Hot-water rinse and neutralize; organic solvents; or degrease
Very good	High	Hot-water rinse and neutralize; 2% HCl solution; hot-water rinse and neutralize; organic solvents; or degrease
Very good, at high temperatures	None normally	None required
Fairly good	Moderate	Hot-water rinse and neutralize; organic solvents; or degrease
Fairly good	Moderate	Same as organic acids
Fair	None normally	Hot-water rinse and neutralize; organic solvents; or degrease
Fair	None normally	Water-base detergents Isopropyl alcohol; organic solvent; or degrease
Poor	None	Same as activated W/W rosin, but does not normally require post-cleaning

Corrosion stems directly from the flux and must be controlled, or the soldered joint may weaken or fail in fatigue. In electrical connections, these troubles may be compounded by change in electrical characteristics. Further, corrosion products can lower the insulation resistance or bridge the components, causing short circuits. Consequently, a good industrial flux should have low corrosiveness because when the flux is applied and melted, it may lodge in crevices or other hard-to-reach areas; fumes liberated during soldering may condense on the assembly away from joint and might not be removed when the joint area is cleaned; flux residues may drain into inaccessible areas. If corrosiveness cannot be controlled, be sure that the selected flux and its residues will be easy to remove after soldering.

Safety must consider both the handler of the material and the plant itself. The flux should be a nonirritating material with harmless fumes given off during soldering. It should have a flash point substantially higher than the soldering temperature, and a decomposition rate slow enough to prevent explosion in case of overheating. The ideal flux should also be inert to materials it might nor-

FLUXES FOR ELECTRICAL CONNECTIONS

Corrosion products and flux residues are a special hazard in electrical connections because they may short-out circuits, or cause current leakages.

If the assembly can be thoroughly cleaned after soldering, any suitable flux may be employed. However, many electrical and electronic assemblies are sensitive to moisture or organic solvents, making it impractical to remove flux residue. Here, the rosin-base fluxes have come into their own. They fall into two major categories:

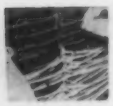
Water-white (W/W) rosin, as a flux for the electronics industry, is a controversial material. It has many uncontested qualities but does not fulfil all the requirements for efficient fluxing. As can be seen from Table II, p 48, few metal surfaces can be soldered with it, and then only under favorable conditions.

Rosin is the nonsteam-volatile fraction that remains when pine sap is processed; its specific composition varies with the source of the raw materials. In general, it is a mixture of several isomeric diterpene acids. The major component is abiatic acid, which makes up 80 to 90% of the average rosin. W/W rosin is an extremely pure grade of material (see ASTM Designation, D509-55).

It is a rather sensitive flux that loses its tarnish-removal capacity when overheated. (This can be partly solved by allowing a long fluxing time at a lower, more active temperature range.) It reacts with copper oxides and sulfides to give a green copper abiate which is electrically inert. This green residue is often confused with copper corrosion products, which are electrical conductors when moist.

When relatively clean surfaces are involved, W/W rosin makes a very safe flux, which can be left on under most environmental conditions. In an inert vehicle like isopropyl alcohol, it is the least corrosive flux available at present. The flux residue is a hard transparent material, which is an excellent electrical insulator.

Activated-rosin fluxes have organic and inorganic materials added to improve tarnish-removing capacity. These "activators" remove the tarnish, while the rosin supplies the surface activity and thermal stability. The nature of the activator determines the corrosiveness of the flux, and many proprietary fluxes are so formulated that the activator will decompose or evaporate at soldering temperatures, leaving a pure rosin residue behind. Any claim for complete decomposition of activator should be viewed with caution, because the activator needs enough exposure to the right temperature to be completely removed. In practice, it is hard to determine whether enough heat and time are provided for all of the flux present, and any unused activator in the residue is a potential source of trouble. It is good practice, therefore, to remove the residues of activated fluxes. In doubtful cases, specifying a cored solder will also minimize the problem. Where it is necessary to leave the flux residue on the work, pure W/W rosin should be specified.



SOLDER FLUX continued

Table II – Flux Guide for Engineering Metals

Code: 1 – Normally used · 2 – Used only under favorable conditions · 3 – Not normally used

	METAL SURFACES	INORGANIC	Nonrosin ORGANIC	Rosin W/W	Organic Activated
SOLDERING EASY	Brass	1	1	2	1
	Bronze	1	1	–	2
	Cadmium	3	1	2	1
	Copper	3	1	2	1
	Gold	3	1	2	1
	Lead	1	1	2	1
	Nickel	1	1	–	2
	Palladium	3	1	2	1
	Platinum	3	1	2	1
	Silver	3	1	2	1
	Tin	3	1	2	1
	Tin-lead (hot dip)	3	1	2	1
	Tin-lead (plate)	3	1	2	1
	Tin-nickel (plate)	3	1	2	1
	Tin-zinc (plate)	3	1	2	1
SOLDERING LESS EASY	Aluminum	–	–	Special solder & flux	
	Beryllium copper	1	2	Special flux only	
	Cast iron	1	–	....	
	Copper alloys	1	2	....	
	Germanium	1	2	....	
	Inconel	2	–	Special flux only	
	Kovar	1	2		
	Magnesium	–	–	Special flux only	
	Monel	2	–	Special flux only	
	Nichrome	–	–	Special flux only	
	Rhodium	1	2	....	
	Rodar	1	2	....	
	Steel	1	2	....	
	Steel (galvanized)	1	2	....	
	Stainless steel	1	–	Special flux only	
	Zinc	1	2	....	
	Zinc (die-cast)	–	–	Special flux only	

Note: These metals are normally not soldered: beryllium, chromium, molybdenum, niobium, silicon, tantalum, titanium, tungsten, zirconium.

mally contact. Directions for proprietary fluxes usually cover these points.

Economics is a self-explanatory factor, though it should be kept in mind that an expensive flux can often bring savings later in reliability and avoidance of rework.

COMPARISON OF FLUXES

Dividing fluxes into "corrosive" and "noncorrosive" types, a widely used classification system, is inadequate and often misleading. Many fluxes placed in the first category can be easily handled, and many placed in the second are troublesome under certain conditions. Table I on page 46 shows a better scheme, using chemical origin as a basis. This table identifies and compares the major flux types in terms of the properties discussed above –except for those properties that depend on the total flux/solder/base-metal system and so cannot be tabulated.

The table shows two major flux groups–inorganic and organic materials:

Inorganic acids and salts are fast-cleaning and will remove any common tarnish. They are stable and active at soldering temperatures, but very corrosive before and after soldering and their condensed fumes must be removed. Most of these fluxes are easily removed with water and easily neutralized. Salt fluxes are more widely used and more readily handled than acid fluxes.

Organic materials include acids and halogen compounds, both slower reacting than the inorganic group and less effective in removing tarnishes. Being organic, they are more temperature-sensitive. Organic halogens are similar to the inorganic salts, and are used because of the easily available halogen ions. However, this makes them a bit more corrosive than other organics. Of these other organics, amines and amides are used as additives to many proprietary fluxes, since they don't have halogens themselves. They are only mildly corrosive, but quite temperature-sensitive. Rosin-base fluxes form the last organic group, and these can be combined with other groups to form activated-rosin fluxes. Rosin fluxes are the slowest and least active of all.

CHOOSING THE FLUX

Table I is useful in comparing several flux candidates for a given job, but the first screening must involve the

EXAMPLES OF FLUX SELECTION

Here are two practical soldering problems—one electrical, the other structural.

PROBLEM: Electrical components (resistors, condensers, etc.) must be soldered into an existing electronic assembly that cannot be submerged into any cleaning fluids for flux removal. Limited production is planned at first, so hand soldering is required. Automatic manufacture is anticipated, however, as production increases.

Solution: Restriction on removal of flux residues dictates use of a noncorrosive, nonconductive, nonhygroscopic flux. Table I shows rosin-base solders are best candidates. For better tarnish removal, a solder with activated-rosin core is selected. This also suits the hand-soldering operation, because the activated rosin core does not require meticulous precleaning steps. All flux is contained in the solder jacket; thus all the flux is exposed to soldering temperature during solder melting, insuring deactivated residues.

Automatic soldering, on the other hand, usually requires a dip in liquid flux, followed by dip soldering. Since no corrosion, or current leakage, can be tolerated, W/W rosin should be chosen, coupled with proper prefluxing steps to insure adequately clean surfaces for this mild flux to work on.

PROBLEM: A stainless steel tape is to be soldered to a plated steel block. Assembly requirements are such that no flux removal is possible in the final assembly. Plating chosen should prevent rusting of the plain steel block under operating conditions, and have a pleasing appearance.

Solution: Principal problem is the stainless steel, a metal that requires a special, highly corrosive flux (Table II). This flux cannot be used at final assembly, since washing is precluded. However, the stainless tape can be pretinned, using this flux, and all corrosive residues washed off before final assembly. Then, with a mild, noncorrosive flux, the pretinned tape can be soldered into the assembly.

Cadmium plating is tentatively selected as a compromise among appearance, corrosion resistance and cost. Further surface treatment on top of the plating, such as a colored conversion coating, is ruled out, as it impairs solderability. A check on cadmium in Table II shows it can be soldered with W/W rosin flux if conditions are favorable, but that normal practice would call for either a nonrosin-base organic flux or a flux with activated-rosin base. A check in Table I shows the latter to be least corrosive of the two. In summary: Use an activated-rosin flux to solder pretinned stainless to cadmium-plated steel.

metals to be joined—the starting point of any soldering problem. Table II therefore lists which flux types are preferred for which metal surfaces. It shows that, under favorable conditions, many mild fluxes are satisfactory—an important factor in electrical applications.

Most handbooks give adequate guidance on choice of solder for the metals to be joined. Once the solder/base-metal combination has been selected, Tables I and II may lead to several possible fluxes. The final choice will then depend on other factors such as flux cost, pre- or post-soldering steps required, importance of residues, need for automatic procedures and the like.

WRITING THE SPECIFICATIONS

Choosing a flux with discretion is not enough; there must be some insurance that it is used properly. This can be done, in part, by spelling out the proper flux and solder procedure in the design specifications. In general, be sure to cover the following points:

Flux type desired should be plainly specified. Choice of flux brand should be left to manufacturing personnel who, in turn, can draw on past experience. Government agencies, trade associations, and technical societies have flux standards (Table III) to which flux manufacturers pay close attention. These can serve as additional guides.

Prefluxing steps may be necessary. Fluxes will not remove surface dirt, which will often render the flux inactive. If heat-treat scale is present, specify a descaling step. In general, the same precleaning procedures used for electroplating will suffice (surfaces should be dry, however). If a soldered subassembly used a corrosive flux and if total removal of residues is in doubt, specify pretinning of parts before assembly, together with proper cleaning. This will remove all corrosive residues and allow mild, noncorrosive fluxes to be used in the final assembly.

Table III – Major Soldering Standards and Specifications

SOURCE	DESIGNATOR	SUBJECT
US Govt	QQ-S-571c Mil-14256A Mil-S-6872A	Solder and Flux New Flux Spec Soldering Process
Underwriters' Laboratories (UL)	381-O-o	Soldering Fluxes and Fluxed Solders
Electronic Industries Assn (formerly RETMA)	RS-178	Solderability Test Standard
ASTM	B-32 B-284-53T	Soft Solder Metals Rosin-flux Cored Solder

Method of flux application is determined by the specific application, which may allow any of several: dipping, spraying, brushing, rolling, etc. Flux concentration and its vehicle should be specified, along with any special precautions regarding vehicle stability.

Soldering parameters such as temperature, type of heat source (torch, electric iron, solder pot, resistance tools, etc), and safe ventilation should be checked for compatibility with the flux, then specified.

Post-soldering steps may be needed because the joint—as well as adjacent areas—will be covered with flux residue, spattered flux and possibly flux condensate. Two procedures are possible: For corrosive fluxes and residues, removal is necessary—particularly in electrical connections. Specify flux-vendor recommendations or rinse with dilute

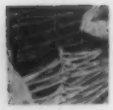
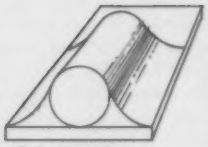


Table IV – Solder-joint Inspection Chart

GOOD WETTING. Solder is feathered out, indicating a small dihedral angle. The solder surface is bright and smooth, with few or no pinholes.

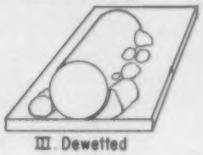


I. Good wetting

POOR WETTING. Solder makes a large contact angle (75 to 90°). Solder surface is not continuous; irregularly round, nonwet areas are exposed. Normally a small amount of this condition can be tolerated.

II. Poor wetting

DEWETTED. Solder forms in balls, does not completely cover the surface, and has contact angle greater than 90°. This condition should not be tolerated.



III. Dewetted

INSUFFICIENT HEAT. Solder solidifies in a nonadhering continuous layer because flux is not properly activated. Usually a film of tarnish is still present on the work, and the solder can be pried loose. Contact angle large, but varied.

IV. Insufficient heat

ROSIN. Bond is achieved through a layer of solidified flux, usually a rosin type. In its worst form, this joint has no metallic or electrical continuity, and has little physical strength. Contact angle poorly defined though fillet is continuous.

V. Rosin

COLD. Joint appears frosty and granulated because of movement during solder solidification. In its worst form, it is the "fractured joint" shown at left in the sketch. Contact angle usually OK.

VI. Cold

Table V – Checklist for Flux Selection

1. Does the job require precleaning of metal surfaces?
2. Will the flux promote soldering under production conditions?
3. Is it the least corrosive flux that will do the job adequately?
4. Can the corrosive residues, if any, be easily removed?
5. Does the flux lend itself to the production techniques desired?
6. Will the flux be used in its proper temperature range?
7. Is the flux vehicle suitable for your temperature conditions?
8. Are flux and vehicle both safe under production conditions?

Training Film

Operator training and critical, visual quality control are as vital to good soldering as proper flux selection and specification. To emphasize this point, IBM has prepared a 13-minute training film entitled "The Art of Soft Soldering." In sound and color, this film is available for training purposes on a free-loan basis by writing to: Dept of Information, IBM World Headquarters, 590 Madison Ave., New York 22.

HCl followed by water and/or neutralize dip for inorganic fluxes; for organics, solvents or water-base detergents will suffice. Be sure that all identification marks on components are resistant to the solvent used. For noncorrosive fluxes, leave the residue on. Just be sure that it is hard, nontacky, nonhygroscopic, and a good electrical insulator.

Inspection of the finished joint, short of destructive testing, is limited to visual examination. There are, as yet, no engineering criteria for solder-joint evaluation beyond the use of the dihedral angle. Acceptable limits for this wetting angle should be clearly specified. Table IV lists several categories of inferior connections, applicable to both electrical and structural joints, that should be avoided. As experience is gained, a well-trained operator, who follows specifications can obtain consistently good joints.

The checklist given in Table V provides a final yardstick for flux selection. A quick run through this list will ensure that no major factors have been overlooked.

REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, N. Y.

EDITOR'S NOTE: Other recent articles on the special problems of joining metals:

Pinpoints Best Soldering Connections, Apr 25 '60, p 44—Tester checks temperature, surface condition of metal, composition of solder and flux.

How to Choose the Right Electrical Connection, Dec 7 '59, p 71—Here for the first time are direct comparisons among all electrical connection methods—permanent and separable. Articles gives data from all known sources.

new standards needed for . . . MOTOR PROTECTION

Safeguards can be simpler now, thanks to small detectors that monitor temperatures right in the motor windings. Here are reasons why our present standards—written around slower-acting thermostats —are becoming obsolete.

FRANK YEAPLE, *associate editor*

ACKNOWLEDGMENT

This article was prepared with help from John J. Courtin, senior design engineer, Motor Dept, Westinghouse Electric Corp, Buffalo. His department recently introduced a line of Westinghouse Guardistor motors. These are ac-type, with inherent over-temperature protection using positive-temperature-coefficient-thermistors.

Obsolete electrical standards can cost you money, particularly in the case of overload protection for motors. Too often, we find two devices—for over-temperature and over-current protection—are often specified when a single one could do.

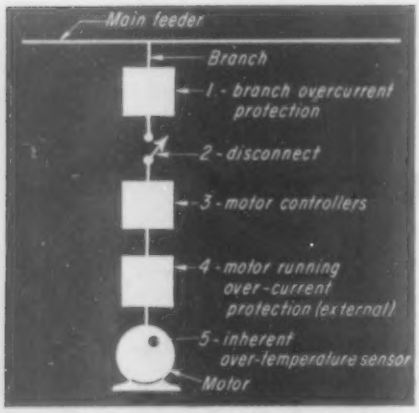
Over-temperature of motor windings—whether in ac or dc types—is almost always the basic danger to guard against. An over-current device external to the motor is one way to get that protection. A more direct way—thanks to small, fast-acting, reliable, temperature-sensing elements now available from many manufacturers—is to imbed the protection right in the motor windings.

Unfortunately, most of the existing electrical standards assume that temperature detectors act too slowly, and they specify over-current relays as backups. This is why today's need is for a set of revised standards, and why such are now being worked on by an NEC (National Electric Code) group. These standards, based on modern technology, will ensure that protection is adequate but not redundant.

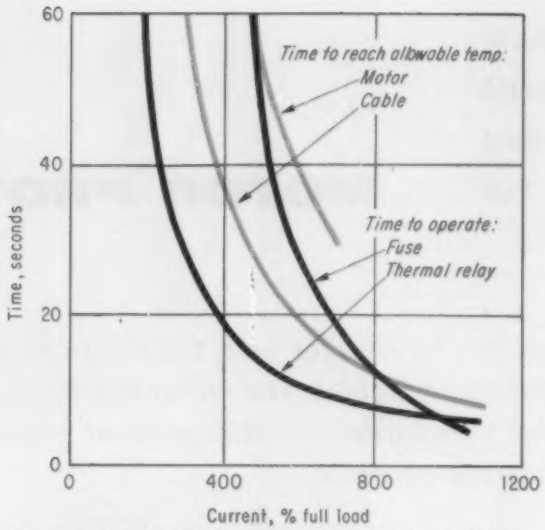
WHAT THE STANDARDS SHOULD COVER

First necessity is to recognize that motor protection cannot be completely divorced from circuit protection. Over-all protection includes branch conductors (from the power line), controls, motor windings, and adjacent or related circuits. The schematic on next page shows five control elements important to the discussion.

Not all five control elements are needed in every motor application. For example, over-current protection and



THE FIVE MOTOR-PROTECTION ELEMENTS shown in schematic are not all used in every application. Text discusses when each is required.



SPEED OR RESPONSE of each important circuit element must be known before proper selection of protective devices can be made. Here is typical motor and branch response. Inherent over-temperature sensor will be at motor temperature, tripping quickly at chosen set point.

the disconnect for a branch can often be combined in a circuit breaker. And there are numerous situations in which one or more of the elements—including motor over-current protection, which is intended to protect motor windings and branch conductors from overheating—can be eliminated if safety is ensured by other devices elsewhere in the branch or feeder.

All of this is carefully spelled out in the National Electric Code, as is explained below. But other standards-writing groups do not allow so much leeway—particularly regarding motor over-current protection. They insist on external motor-overload devices (thermal or magnetic) where inherent (in-the-motor) over-temperature sensors would do.

TODAY'S STANDARDS

Basic electrical standard for all standards-writing groups is the National Electric Code (NEC), sponsored and published by National Fire Protection Association (NFPA), 60 Batterymarch St, Boston. The American Standards Association (ASA) has approved the NEC as an American standard. National Board of Fire Underwriters (NBFU) also accepts NEC as a standard.

NEC standards are flexible enough to allow inherent (in-the-motor) over-temperature protection—without current-responsive overload relays for backup—in many circumstances.

However, motor-using industries can adapt basic NEC rules to suit the particular conditions of each industry . . . and these versions are usually stricter than those considered in the NEC.

For example, Joint Industry Conference (JIC) Standard E13.4.1 specifically states: "Each motor shall be protected against running overload by the use of a separate overload device responsive to motor current or to both motor current and temperature." It recommends an inherent (in-the-motor) over-temperature protector only when "short-time-rated or high-reversing-duty motors . . . cannot be adequately protected by external overload devices." And even then it specifies: "In addition (such) motors shall be protected against stalled conditions by the use of a protective device which is responsive to motor current."

National Machine Tool Builders Association (NMTBA) Standard 13.4.2 follows the reasoning of JIC regarding short-time-rated and high-reversing-duty motors, allowing inherent over-temperature protection, but stating: "In addition they shall be protected against stalled conditions by use of a protective device which is responsive to motor current or to both motor temperature and current."

Objection to the NMTBA and JIC adaptations of NEC is mainly this: There are many applications in which either one or the other—external overload protection, or inherent over-temperature protection—will do. Why not permit such exceptions in the wording of the standards?

HOW NEW STANDARDS CAN HELP

These typical circumstances demonstrate that the design engineer must have more leeway in deciding the type and amount of protection needed for circuits and motors:

Branch Overloads. Branch fuses are usually simple, fast-acting links designed to melt at about 400% motor current. Current overload relays in each designated phase of the branch operate at about 125% motor current (a typical case) to protect motor and branch circuits from overloads between 125% and short circuits. It might be possible (assuming that standards-writing groups agree) to eliminate the over-current relays and absorb their function in the branch fuses.

For example, the 400% quick-acting fuse could be replaced by the 200% time-delay type. Continuous overload above 200% would be prevented, but nuisance trips on short-time-overload—even stalling—would not occur. The inherent temperature-detectors would meanwhile be there to prevent motor overheating.

Branch Conductors. Cable-sizing practices today result in conductors that overheat more rapidly than the motor under certain overload conditions. Thus, they depend upon external over-current devices for protection. Yet if standards specified slightly larger cables—a good idea—then the over-current devices could be safely eliminated in many instances. And inherent over-temperature sensors will still protect the motor windings.

Another answer to conductor protection is to place temperature-sensing elements—connected into the motor-control circuit—in the cable insulation.

Running Overload. Assuming external circuitry is properly sized—new standards are needed to assure this—then overloads can be safely limited by temperature sensors in the stator windings for motors of any size. Unless the motor overheats, there is no need to trip it out on momentary overload.

Stalled Rotor. Causes can be mechanical (jammed gearing, excessive overload), or electrical (loss of phase, drop in voltage). Result is continuous current—many times higher than normal—that heats rotor, stator and external circuitry at rates depending on relative impedance and mass of parts.

If branch conductors and other external circuitry have been properly designed (specific standards should define the limits), then over-current caused by stalling will seriously overheat the motor only. For ac motors less than 200 hp, the stator-winding temperature is a reliable indication of over-all motor temperature. Here, fast-acting temperature sensors—without help of thermal or magnetic relays that respond to current—give adequate protection. However, for larger motors, the rotor temperature will increase too rapidly compared with that for the stator, and stator-mounted detectors will usually not be adequate for stall protection; therefore over-current relays are needed.

Unusual Duty Cycles. No standard can anticipate every duty cycle. Those too unusual for consistent standards must be over-protected in many cases. The less predictable the cycle, the more reason to install the protection within the motor windings, along with external protection, too, if necessary.

Direct-current Motors. It's harder to protect dc motors than ac induction motors. For one thing, the main winding (armature) is rotating, and electrical connections must be made via the commutator. Furthermore, electrical impedance is less and current surges can be more serious. Most standards cover both dc and ac motors. Ac induction motors are most common, so will benefit in greater proportion from improvements in standards.

Ambient Conditions. Poor ventilation, dust accumulation, hot days, and wide temperature variations between motor and control enclosure can alter operating point of external protective devices, causing either nuisance trips or failures. Inherent sensors are not affected, and trip out when winding temperature reaches set value.

Reduced Cooling. Sealed refrigerator motors, and other motors normally kept unusually cool with available fluids, can overheat on system loads that are small if rate of cooling becomes too low. Best protection here is with temperature sensors in windings, because overload relays do not operate on abnormally low currents. It is also possible to eliminate some mechanical protective devices such as oil-failure and low-pressure switches—if winding-temperature sensors are recognized by the standards to be reliable for the application.

EDITOR'S NOTE: Details of all types of inherent over-temperature protectors will be given in a forthcoming article. New NEMA standards for motors and controls have been discussed in these previous articles:

NEMA Standards for Those Size-reduced Motors, Feb 3 '58, p 54—Explains and summarizes the new NEMA frame designations.

Control Enclosures, June 23 '58, p 78—Explains the NEMA standards, describes safeguards, minimum ventilation, and other requirements of NEMA, UL and JIC.

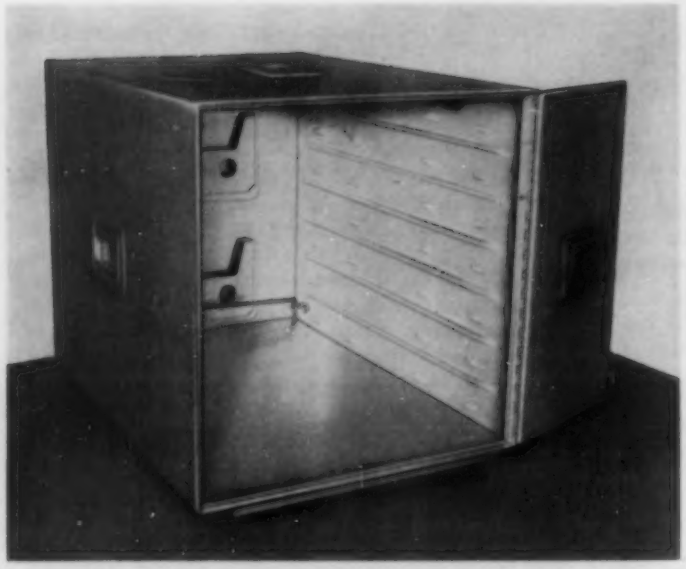
For more details on motor protection and control see:

Duty-cycle from Motor-winding Resistance, Jan 25 '60, p 64—Describes Seely Box that determines motor temperature under load by bucking ac with potential transformer, adding isolation capacitor.

Here's Help in Selecting the Right Motor, Oct 13 '58—A bibliography of previous Product Engineering articles on motors and controls.

Fuses Do This, Jan 6 '58, p 64—Describes single and dual-element fuses, explains NEC rating methods, recommends good fusing practices.

Motor Overload Relays, Jan '55, p 77, and **Safety in DC Motor Controls,** Dec '55, p 193—They tell how to select the right relay rating.



Food-tray carrier for airliner has 7/16-in. all-aluminum honeycomb panels with flexible corners bonded with modified epoxy resin. Total panel weight (0.236 lb/sq ft) saves 4 to 5 lb over earlier design using riveted corner construction. Door is spring-closed.

CORNER CONSTRUCTION

for joining sandwich panels

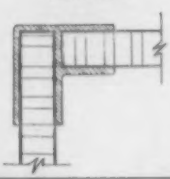
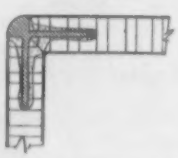
ORVIL S TUTTLE, *technical director*
Monogram Precision Industries Inc

Any shipping container suitable for permanent storage, when designed for air shipment, requires sturdiness to withstand rough handling with minimum weight. Structural sandwich offers possibilities, but adequate strength, good sealing, and corner flexibility are difficult problems with some types of corners. Assembly labor can be high for tricky designs, and panel thickness also can be critical.

As applied to a typical test bench for aircraft fire control, relative cost and weight for four types of corner construction are shown in the table, along with the advantages and limitations of each type of construction.

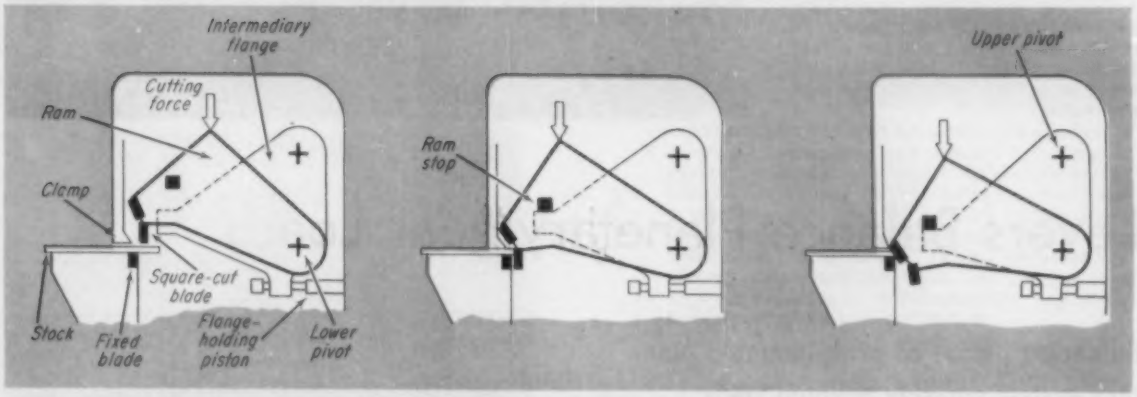
The bonded type with the inserted corner gives the lowest weight and cost, has the desired flexibility, avoids sealing problem at corners, takes standard panels with little or no tooling. Brackets, channels and other details required inside the container can be added before panel assembly. In addition, the construction is adaptable to short runs as well as large containers.

COMPARISON—4 Types of Corner Construction
for a fire-control test bench

	RIGID	FLEXIBLE	BONDED	BONDED
				
Relative Cost	2.1	1.1	1.2	1.0
Weight Index	1.3	1.1	1.1	1.0
Flexibility	Stiffer than panel	10% of panel stiffness	Stiffer than panel	10% of panel stiffness
Watertight Sealing	Difficult at corner intersections	Cement-sealed; no corner problems	Tricky corner intersections	No problem
Panels	Edge banding required	Standard panels cut to size	Thickness is critical	Standard
Drilling	In assembly or with templets		None	No tooling
Labor	In proportion to linear dimensions		——	Less skill required
Meet Military Drop-test?	No	Yes	——	Exceeds specs

Same Stroke— 2 Different Cuts

Only one press and one operation are needed to lop off metal plates and bevel them. It's done by automatically switching from one pivot point to another in midstroke.

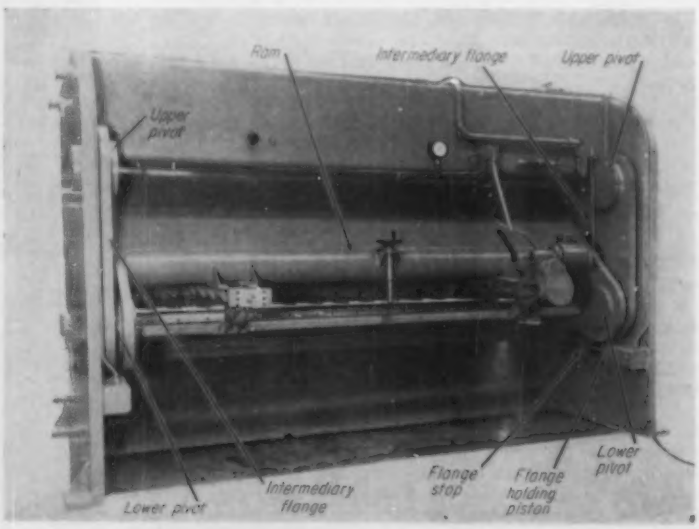


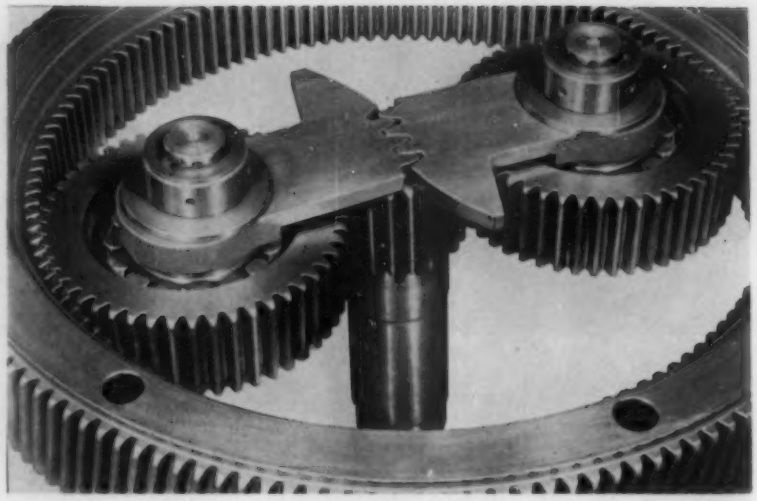
TWO PIVOTS and the intermediary flange govern sequence of cutting action. Flange is connected to the press frame at the upper pivot. The cutting ram is connected to the flange at lower pivot. In first part of cycle, the ram turns around the lower pivot and shears the plate with the square-cut blade; motion of the intermediary flange has been restrained by the flange-holding piston.

After the shearing cut, the ram stop bottoms on the flange. This overcomes the restraining force of the flange-holding piston and the ram turns around upper pivot. This brings the beveling blade into contact with the plate for the bevel cut.

AUTOMATIC PIVOT-SWITCHING is accomplished by the ram stops and by cutting the flange-holding piston out of the hydraulic circuit after the shearing operation. Movement of the flange stops provides adjustment of the shearing cut, and ram stops provide adjustment of the beveling operation. Entire plate edge can be beveled, or a partial bevel can be cut, leaving a vertical shoulder. Retractable steel balls on the worktable permit two-man positioning of heavy steel plate for cutting. When plate is clamped for shearing, steel balls retract.

PS . . . Cutting and beveling plates before welding usually requires the use of two presses, one for each operation. Single-press operation eliminates handling required to move stock between shearing and beveling operation. At full capacity (handling 1-in.-thick plate, 10 ft long) press can make 8 strokes per minute. Unloaded press cycles in 4 seconds. Three models (for ⅝, ¾ and 1-in. plate thickness) are produced by Carpet Louvet & Co, La Courneuve, Seine, France.

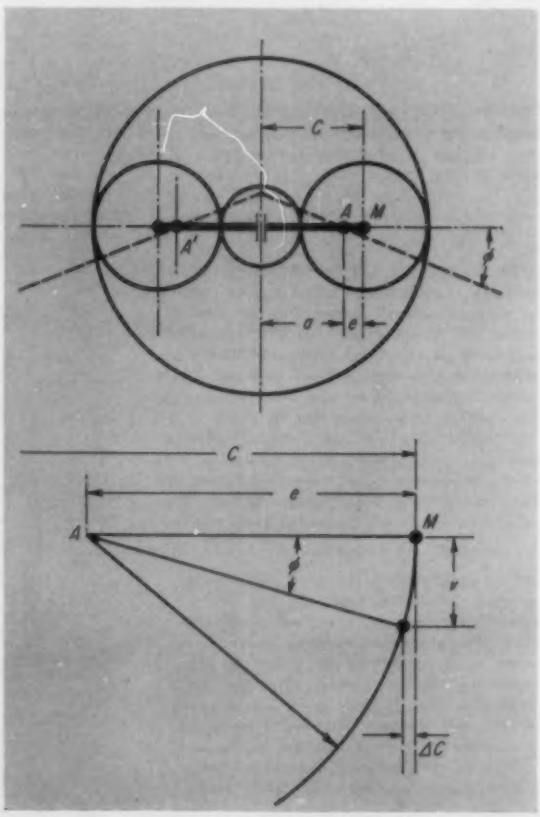




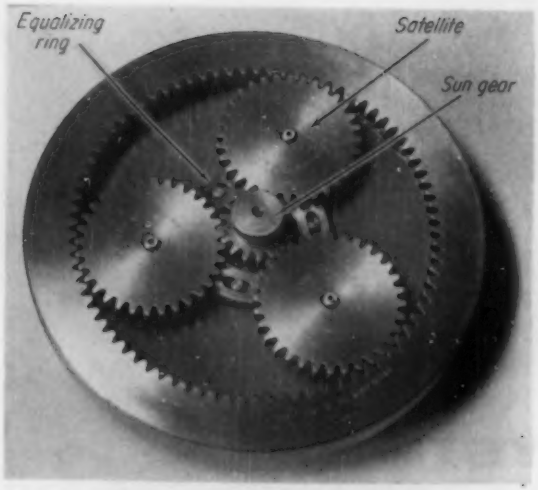
EQUALIZING LEVERS, which are mounted on eccentric pins of the satellite-gear carriers, are used to balance the load transmitted between the sun gear and ring gear. If one satellite gear receives more than its share of the load, it runs slightly ahead of its mate. But as it moves ahead, the overloaded satellite pivots the balancing lever on which it is mounted. This motion is transmitted through the opposite lever to force the underloaded satellite into greater contact with the ring gear, thereby equalizing the load. Thus, these permanently meshed equalizing levers compensate for machining and mounting errors of the planetary parts. Load on the equalizing levers is low, permitting levers of as little as 1/15th the ring-gear width.

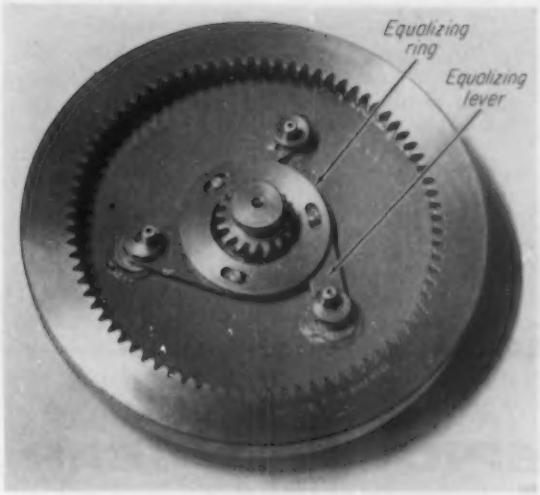
Levers Balance Planetary-gear Loads

Balancing action of pivot-mounted planetary system corrects unequal loads on satellite gears. This reduces manufacturing cost, increases allowable load factors, and permits use of parts with wider tolerances.

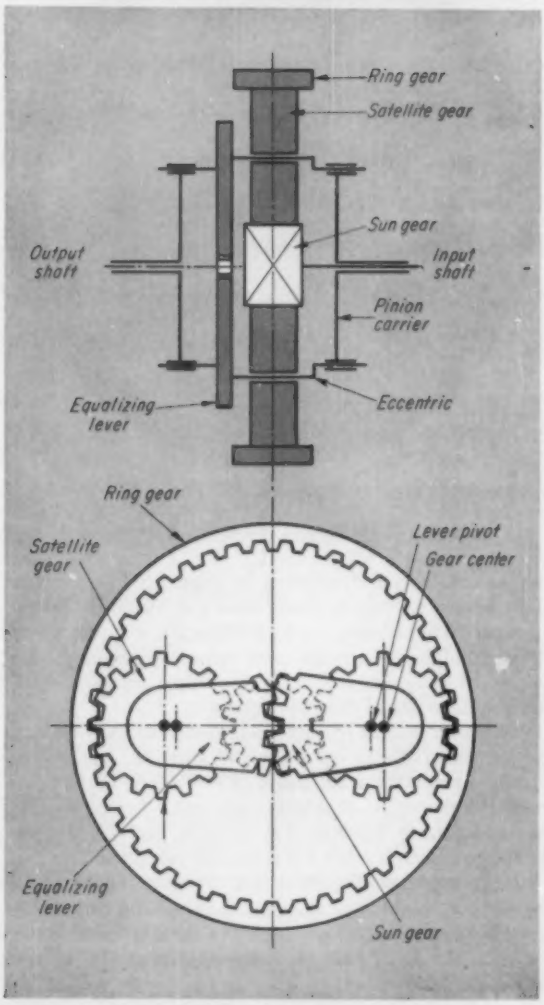


PIVOTING ACTION of levers compensates for unequal loading. The satellites travel through arc V whose radius, e, is equal to the eccentric off-set AM. Angle ϕ subtended by this arc equals the angular deviation of the equalizing levers from a line, AA' between the pivot points of the satellites. The radial distance, ΔC, along the system centerline between points on the arc is the axial distance error. This axial error equals the distance the satellites can travel to compensate for allowable manufacturing tolerances and the resulting unequal loading. Conventional planetary systems, with no such compensating mechanism, would require much closer tolerances, and higher production costs, to assure equal loading.





THREE-GEAR PLANETARY SYSTEM achieves a constant mechanical load balance by using a slotted equalizer ring to absorb the load variations transmitted by the three equalizer levers. The floating equalizer ring is mounted on the three levers and positioned by load conditions when the transmission is in motion. During operation, the centers of the equalizing ring and the sun gear do not necessarily coincide, since the ring shifts to compensate for unequal loading.



POWER FLOWS through gear train as follows: input at the sun-gear is transmitted to the satellites, which rotate on the eccentric shafts and engage the ring gear. Eccentric-pin carrier serves as output shaft. The equalizing levers are keyed to the eccentric pin and connected to each other by geared segments at the center. Uniform loading at all four points of contact between gears is assured by the balancing effect of the equalizing levers.

PS . . . Developed for use in cranes, hoists, cable cars and mining machinery, pivoting transmission allows lightweight, high-capacity planetary systems. Actual production cost of twin-gear planetary system compares favorably with simple gear-and-pinion reducers of same size. Produced by Simmering Graz Pauker A. G. Vienna, Austria.

volume requirements of

EPICYCLIC GEAR SYSTEMS

Equations for volume of spur or helical trains don't apply to epicyclic systems, where power flows through several planets. The author therefore modifies the equations—to provide a systematic analysis of volume, power capacity, speed ratios and stresses.

(For the latest development in an application of epicyclic gearing—supplying the planetary system with load-compensating levers—see p 56.)

ROBERT J WILLIS JR
Lightweight gear application engineer
General Electric Co, West Lynn, Mass

For epicyclic gearing we need more than the standard equations that guide the preliminary design of spur or helical gears. As written, such equations do not allow for the multiple power paths in the planetary or star gear systems. But they can be adapted for the purpose. The following two equations, found in D. W. Dudley's book, *Practical Gear Design*, serve as a starting point:

$$C^2F = \frac{31{,}500\,Q}{K}; \text{ Where } K = \frac{W_t}{Fd_p}\left[\frac{m_g + 1}{m_g}\right] \quad (1)$$

$$Q = \frac{\text{horsepower}}{\text{pinion rpm}} \times \frac{(m_g + 1)^2}{m_g} \quad (2)$$

Substituting for Q in Eq (1)

$$C^2F = \frac{31{,}500}{K} \times \frac{\text{hp}}{n_p} \times \frac{(m_g + 1)^2}{m_g} \quad (3)$$

Since, by definition,

$$C = \tfrac{1}{2}(d_p + d_p m_g),$$

$$C^2 = \left[\frac{d_p}{2}(m_g + 1)\right]^2$$

Substituting C^2 in Eq (3) gives

$$Fd_p^2 = \frac{126{,}000 \times \text{hp}}{Kn_p} \times \left[\frac{m_g + 1}{m_g}\right] \quad (4)$$

The various factors required to solve Eq (4) are normally known, or can be made readily available in normal practice. The solution indicates that for a given set of design conditions a specific rotor volume is required—the volume of a cylinder formed by the active gear-face width and the diameter of the pitch circle.

Once rotor volume has been determined by Eq (4) for a specific set of design conditions, it must be kept. It is possible to vary the relationship of face width to diameter so long as their product remains constant. For high-speed precision gearing, however, it is not good practice to allow the face width to become too large with respect to gear dia. This can cause misalignment and bending, and lead to load-carrying problems. It is well to limit the face width to 60-70% of the gear dia, unless a double-helical set is used. In the latter case the individual faces should not exceed the 70% value.

In practice, Eq (4) must be altered to account for the effect of the number of planets designated by b—Eq (5) below. (The possible number of planets in an epicyclic gear is further explained by the author in his PRODUCT ENGINEERING article, Nov 24 '58, p 57.)

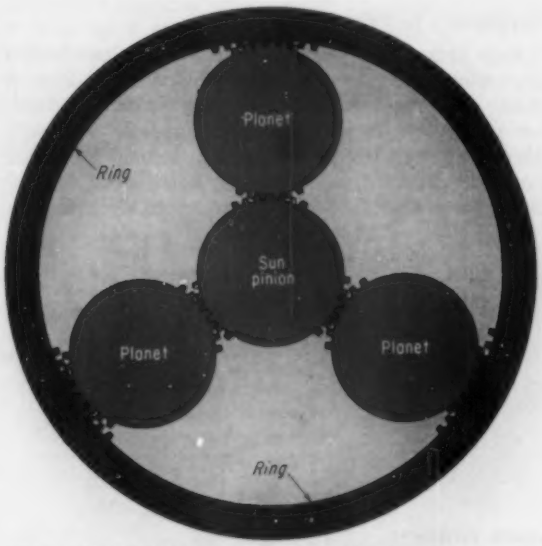
$$Fd_s^2 = \frac{126{,}000 \text{ hp}}{b K n_s} \left[\frac{m_g + 1}{m_g} \right] \quad (5)$$

For a simple planetary gear

$$m_g = \frac{M_o - 2}{2}$$

and for a star gear

$$m_g = \frac{M_o - 1}{2}$$



STAR GEARING is a variation of the basic planetary gear system. Geometry of these two types is the same; difference is in the ratio of output to input.

Other basic equations used are:

$$W_t = \frac{126{,}000 \text{ hp}}{b n_s d_s} \quad (6)$$

$$U = \frac{W_t P_d}{F \cos \psi} \quad (7)$$

Eq (7) applies to both straight spur and helical gear designs. For spur teeth, where helical angle is zero, cos ψ equals 1.0.

The reasons for using helical teeth in epicyclic gearings are the same as in normal gearing practice:

- Helical gears run more smoothly at high rpm.
- Helical gears tend to dampen disturbing dynamic or vibration frequencies.
- Double helical gears will cancel end thrusts and permit free floating of the sun pinion.

SYMBOLS

b — Number of planets	M_o — $(d_R/d_s) + 1$, overall epicyclic ratio for planetary gear
C — Center distance, in.	n_s — Number of sun teeth
d_p — Pitch diameter of planet gear, in.	n_p — Number of planet teeth
d_R — Pitch diameter of ring gear, in.	P_d — Diametral pitch
d_s — Pitch diameter of sun pinion, in.	S_c — Compressive stress, psi
F — Face width, in.	S_t — Tensile stress, psi
m_g — Speed ratio. $(m_g + 1)^2/m_g$ is ratio factor	S_t' — Tensile stress for reverse loading, psi
m_s — d_p/d_s, ratio of planet to sun pinion	U — Unit load, lb/in. of face width
	W_t — Tangential force, lb

When using double helical gearing, you must split the ring gear to allow for assembly.

Putting Equations to Work

The following steps, using arbitrary but representative figures, show how to get preliminary design data from these equations.

1. Solve for rotor volume, using Eq (5) and the calculated value of m_s. Suppose the answer is $Fd_s^2 = 25$.

2. Solve Eq (6) for tangential driving load. Since the sun-pinion diameter is one of the unknowns in the general problem, no numerical value is substituted for d_s. The result might be $W_t = 18{,}000/d_s$.

3. Choose a value of unit load. For high-speed high-power precision gear sets, a value of 12,000 to 13,000 lb/in. will result in reasonable root stresses for limited-life designs. Table below shows typical unit loads based on 100,000,000 cycles with reversed bending load accounted for. Substitute the value found for W_t above into Eq (7) and solve for Fd_s. For our example:

$$Fd_s = 1.05 P_d$$

TABLE OF UNIT LOADS

Material	Hardness, R_c	U
(Carbon Steels)		
Furnace Hardened & Machined	33–38	6000–8000
Carburized Ground Fillets	58–63	9000
Flame or Induction Hardened	48–53	9000
Carburized Unground Fillets	58–63	12,000
Carburized, Special Design With Rigid Quality Control	60 min	15,000

4. There are now two equations with the factors F and d_s available in useful form. By solving these two equations for F and setting them equal to one another:

$$\frac{25}{d_s^2} = \frac{1.05 P_d}{d_s} \text{ or}$$

$$d_s = \frac{23.809}{P_d}$$

5. A table as shown in sample problem later is now made, listing various values for d_s and P_d.

At this point engineering judgment will guide the de-

signer to the best combination. For example, a specific application may have size limitations, yet the value of diametral pitch which results in the proper-size gear set may not be what the designer considers ideal. Some considered maneuvering with the variables is necessary to arrive at the required design objectives—minimum weight and size.

Taking the above basic equations a step further in our derivation by substituting the W_t in Eq (6) into Eq (7) gives:

$$U = \frac{126{,}000 \text{ hp } P_d}{b\, n_c F\, d_c} \tag{8}$$

or

$$Fd_c = \frac{126{,}000 \text{ hp } P_d}{b\, n_c U} \tag{9}$$

By solving for F in Eq (5) and (9), and setting results equal, the following fundamental equation for d_c is obtained:

$$d_c = \frac{U}{K P_d}\left[\frac{m_c + 1}{m_c}\right] \tag{10}$$

It must be noted that in epicyclic gearing the planet gear is, in effect, an idler; therefore, the root stress of the sun pinion-planet mesh must not exceed 70% of the max allowable root stress to allow for reversed loading. It should also be realized that the number of cycles, even for a short design life, will be relatively large under normal circumstances, with the result that the stress is at or beyond the knee of the fatigue-life curve. In slower-speed gear systems this might be considered design for an infinite life. In normal practice—that is, high-speed power-transmission gearing—an epicyclic-gear set is classified as precision gearing where there has been careful selection of materials and supervision of manufacturing methods and heat-treating. This is especially true where minimum size and weight are design objectives. For such conditions, the maximum allowable root stress is approximately 54,000 psi. The following equation closely approximates the root stress:

$$S_t \cong \frac{W_t P_d (3)}{F} = 54{,}000 \tag{11}$$

Where reversed loading is encountered, as in the planet gears, it is customary to use as a limit 70% of the maximum allowable root stress:

$$S'_t = \frac{(0.7)\, W_t P_d (3)}{F} = 37{,}800 \tag{12}$$

The value of root stress is directly proportional to unit load (Eq. 7). Therefore, value of unit load for this method is 12,300 lb/in. of face width—and this only when a gear set with very high performance is desired. Actually, gear sets have successfully transmitted approximately 30 hp/lb of structural weight. (Planetary-gear feasibility designs for aircraft made by the author, using this procedure, indicate this figure could be as high as 34 hp/lb.) This weight includes casing structure, bearings, lubrication and oil-scavenge means, but does not include accessory gearing or the lubrication and scavenge pump.

Final Check Points

In applying the above procedure check these points:

- For spur gearing, limit face width of the sun pinion-planet mesh to 60-70% of the diameter of the smallest gear.
- The planet gears are in stress reversal. Be sure the limiting value of root stress is treated accordingly. For spur-gear root stress use Eq (12).
- Check the design for Hertz compressive stress to assure that the limiting value is not exceeded. For 20° spur gear, Hertz stress is $S_c = 5712\sqrt{K}$.
- Check scoring factor or lubricant flash-point temperature. Kelley's method has been found reasonable to apply by actual test determination.

Application to Offset Gears

This method may also be used for the design of offset gears where the value of center distance is not fixed or given. When used for such a purpose, the term b (number planets) is dropped from the equations developed. Also, the factor affecting root stress to account for reverse loading is discarded unless the gear arrangement contemplated has an idler. The following equations are applicable:

$$Fd_p^2 = \frac{126{,}000 \times \text{hp}}{K n_p}\left[\frac{m_c + 1}{m_c}\right]$$

$$W_t = \frac{126{,}000 \times \text{hp}}{n_p d_p}$$

$$U = \frac{W_t P_d}{F} = \frac{126{,}000 \times \text{hp} \times P_d}{n_p F d_p}$$

$$Fd_p = \frac{126{,}000 \times \text{hp} \times P_d}{U \times n_p}$$

$$d_p = \frac{U}{K P_d}\left[\frac{m_c + 1}{m_c}\right]$$

SAMPLE PROBLEM 1

To illustrate the above design procedure, consider the following example:

Data Given	Data Assumed
Planetary Gear	$K = 1000$
$M_c = 5$	$U = 12{,}300$
hp = 3000	
$n_c = 6000$	
$b = 4$	

$$m_c = \frac{M_c - 2}{2} = 1.5 \text{ (for planetary gear)}$$

Solution:

$$Fd_c^2 = \frac{126{,}000 \times 3000}{4 \times 1000 \times 6000}\left[\frac{1.5 + 1}{1.5}\right] = 26.25$$

$$W_t = \frac{126{,}000 \times 3000}{4 \times 6000 \times d_c} = \frac{15{,}750}{d_c}$$

$$U = 12{,}300 = \frac{15{,}750\, P_d}{F\, d_c}\text{; therefore}$$

$$Fd_c = 1.28\, P_d\text{; solving for } F \text{ and equating}$$

$$\frac{26.25}{d_c^2} = \frac{1.28\, P_d}{d_c}$$

$$d_c = 20.5/P_d$$

By choosing various values for d_s and P_d the following table can be constructed.

TABLE FOR EXAMPLE 1

P_d	6	6.12	7	8
d_s	3.416	3.35	2.93	2.565
Fd_s	7.67	7.83	8.95	10.23
F	2.242	2.34	3.06	3.99
d_p	5.125	5.02	4.40	3.85
d_r	17.08	16.75	14.67	12.84
F/d_s	0.658	0.700	1.045	1.554
W_t	4610	4700	5380	6140
S_t	37,000	36,900	36,900	36,900
S_s	———	181,800	———	

Why construct the table when an immediate, specific solution for the variables is possible by substituting $0.6d_s$ or $0.7d_s$ for F after the value of Fd_s^2 was established? Simply because the table indicates the degree of change in each of the variables with constant increment changes of Pd_s and therefore presents a broader picture.

SAMPLE PROBLEM 2

Data Given	Data Assumed
Planetary Gear	$K = 500$
$M_e = 5$	$U = 15{,}000$
hp = 3000	
$n_s = 12{,}000$	
$b = 4$	

$$m_e = \frac{M_e - 2}{2} = 1.5$$

Solution

$$Fd_s^2 = \frac{126{,}000 \times 3000}{4 \times 500 \times 12{,}000}\left(\frac{1.5 + 1}{1.5}\right) = 26.25$$

$$W_t = \frac{126{,}000 \times 3000}{4 \times 12{,}000 \times d_s} = \frac{7880}{d_s}$$

$$U = 15{,}000 = \frac{7880\ P_d}{Fd_s}\text{; therefore}$$

$$Fd_s = 0.525\ P_d\text{; solving for } F \text{ and equating}$$

$$\frac{26.25}{d_s^2} = \frac{0.525\ P_d}{d_s}$$

$$d_s = 50/P_d$$

Again, by using various values for d_s and P_d in the above equations the following table can be constructed.

TABLE FOR EXAMPLE 2

P_d	7	8	9	10	11	12	13	14	15
d_s	7.15	6.25	5.56	5.0	4.55	4.17	3.85	3.57	3.33
Fd_s	3.68	4.20	4.72	5.25	5.77	6.30	6.82	7.35	7.87
F	0.515	0.672	0.849	1.05	1.27	1.51	1.77	2.06	2.36
d_p	10.71	9.36	8.34	7.50	6.82	6.25	5.77	5.35	5.00
d_R	28.60	25.00	22.24	20.00	18.20	16.68	15.40	14.28	13.32
W_t	1102	1260	1415	1575	1732	1890	2045	2210	2370
S_t	———				64,500				———
S_s	———				128,000				———

Analysis

Let us assume that the casing must not exceed 16 in. diameter. A study of the above table indicates:

- The root stress exceeds the max allowable value of 54,000 found in Eq (11).
- The sun pinion is the smallest gear and should have 24 or 25 teeth for good design.
- To fit a 16-in.-dia housing, a reasonable starting point is a ring gear with 13.32 in. pitch dia.
- A ratio of $F/d_s = 0.7$ for the sun pinion should be checked.

Procedure

To choose the most feasible design parameters from the above table proceed as follows:

$$P_d = \frac{n_s}{d_s} = \frac{25}{3.33} = 7.5$$

Check d_s when $F = 0.7\ d_s$

$Fd_s^2 = 28.25 = 0.7\ d_s^3$

$d_s = 3.35$; therefore choice of $3.33 = d_s$ is good.

Check face width by limiting the value of $S_t = 54{,}000$

$$54{,}000 = \frac{2370 \times 7.5 \times 3}{0.7 \times F}$$

$F = 1.411$; Use 1.45

Check F/d_s

$$F/d_s = \frac{1.45}{3.33} = 0.436 < 0.7$$

Check unit load

$$U = \frac{2370 \times 7.5}{1.45} = 12{,}258$$

Summing up:

$U = 12{,}250$
$S_t = 54{,}000$
$P_d = 7.5$
$d_s = 3.33$
$d_p = 5.00$
$d_R = 13.32$
$F = 1.45$
$W_t = 2370$
$S_s = 128{,}000$

For REPRINT of above article, just check P 54 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Epicyclic gearing is a relatively new and rapidly developing concept in power transmission, which will continue to be covered in these pages as additional information is developed. Other recent articles on this subject are listed below.

Epicyclic Gear Train Calculations, Apr '57, p 186—Shows step-by-step calculation of forces and speeds by reducing the train to its component parts and analyzing the center member.

Stress Cycles in Planetary Gears, Jan '57, p 219—Tabulates formulas for number of stress cycles a gear tooth receives during its life.

Formula for Epicyclic Gear Train of Large Reduction, Mid-Oct '57, p E-12, shows configuration and calculations for a reduction of 500:1 or greater.

some problems and possibilities in

PRODUCT DEVELOPMENT

New materials, new production methods, and new methods of analysis and design have greatly increased the engineer's reach. But multiplicity brings its own problems.

E PAUL MEYLAN, *project director*
Consultants for Product Design, Los Angeles

Designers have a saturation point too.

The billions spent in research and development in the past few years have resulted in a bewildering array of new materials, new processes, new components, new packages and infinite combinations thereof. Somewhere along the line the design engineer must call a halt to his library and catalog research—he simply can't absorb (or the budget can't afford) any more.

In a sense this is a human problem and, depending on their personality, men react in two ways.

The conscientious designer leaves no stone unturned in his search for the best for his project. As a result he may never finish. The more realistic and impatient designer throws up his hands in frustration and forces himself into a choice he may regret.

And it's not just a question of what is technically best. You have the compromising factor of cost to consider—and cost today need not be the same as cost a year from now when production starts. Prices of the newer materials particularly are bound to change greatly as larger production or better manufacturing techniques are perfected. Polypropylene, for example, was a good bet. The price dropped satisfyingly as new producers appeared. But not all new materials are as accommodating.

Consumer Complications

When struggling with his compromise between cost and quality, the designer must remember that similar problems of choice face the consumer. Our high standard of living supports many manufacturers of technically equivalent products and so the purchaser of a TV set, a refrigerator, a vacuum cleaner, is faced with dozens of different "lines" in dozens of size or price ranges.

Sometimes consumer frustration results in impulse buying—or buying for strictly emotional reasons. This puts major emphasis on the industrial and package designer's job. Other times the consumer refuses to buy—preferring the familiar hand-operated can opener or egg beater to its complicated (and expensive) electrically powered brother.

Consumers are more size-conscious than ever before. Miniaturization started with the at-any-cost work for defense and astronautics but industry has taken the initiative now with the result that printed circuits, thermoelectricity, semiconductors, and fuel cells are appearing on the department store counters almost before they get off the ground in the latest experimental military hardware.

Reliability—a relatively new term for engineers—refers to something that was easily controlled by the operator at the machine that made manual can openers. Today it is much more important and less easily controlled by the designer of the motorized opener. The modern appliance has bearings and gears to keep clean, an electric switch with a limited life, and a magnetic lid holder not to mention assembly tolerances with all these components.

Automated production lines are a help—the designer needn't worry about fallible human eye and hand. But automation brings its own problems. What we thought of as mass production 20 years ago is beggared by today's production lines. Single design decisions influence hundreds of thousands of dollars in capital investment, and as much or more in finished products. And then decisions must be made long before consumer reactions clearly indicate their interest or disdain for the product.

So the designer is not just an engineer or market analyst, he must be something of an economist as well, or have an economist to advise him. Operations Research is the name given to this whole area of system management and as a mathematical tool it came just in time.

Another result of automatic production in high volume is the modification of the old form-follows-function dogma. New production methods also modify form, and quite distinctly at times. Manufacturers of production equipment for turning, forging, spinning and stretching no longer sell equipment—they sell specialized knowledge and advice.

What trade will do to design

Increased competition for world markets is already upon us—and price is not the only advantage foreign manufacturers have. In the US we tend toward elaborate design

and this shows up as less reliable, less maintainable and, of course, less economical products.

We're blind to many opportunities in world markets because we forget how advanced our living standard really is. For example, the design of a cooking device for relatively primitive markets would be a trying task for many American designers. However, designers in countries not so far up the technological scale may fare much better. Only when the whole world has satisfied the basic necessities of food, shelter and clothing can our more sophisticated consumer products be made desirable—but by then many nations will have designers of that level of sophistication.

Perhaps, eventually, different countries will specialize in components as well as products. We already import tools and dies, vacuum tubes, fasteners and many raw materials for domestically manufactured products. We export many automobile parts, lumber and chemicals. If the trend continues (and Europe's Common Market should accelerate it) where do we stand? What would our specialty be?

We're strong in agricultural and mining equipment, in communication systems and automatic control, in medical equipment, in nuclear products, in chemical products and food processing equipment. Most of our strength is in the diversity of products we offer. We are a rich market with a lot of industrial capital to spend. Perhaps we will be like a large department store competing with many specialty shops.

The conservative tomorrow

We'll have more standards and standardization—and with the emphasis on international trade we can expect a stronger, more influential International Standards Organization. For the more distant future, and with much groaning, there will be final acceptance of a uniform system of units in dimensions and weights. And it is likely to be a metric system.

Government bodies—federal, state, and local—will pass more and more ordinances affecting design (smog control is the most recent example).

Design conservatism is the other side of the standardization coin. Manufacturers are afraid to leave the traditional forms ("How will the purchaser know it's a vacuum cleaner if it doesn't *look* like a vacuum cleaner?"). The price for pioneering will remain high (or go higher) so proven designs with well-established costs will tend to prevail. But manufacturers are not the only conservatives. The consumer of the future is likely to be even more concerned with personal security than he is today, and it may be impossible to lure him away from the familiar form of, say, a television set.

All this seems like a gloomy prediction for the future of originality. But when the world's demands for basic products are satisfied, the small-quantity, high-quality manufacturer will take on more importance. He will be original, but he will produce superbly made, if relatively expensive, products. The return of craftsmanship (and we see movement in this direction already in products for the so-called leisure market) is a heartening sign.

In the more distant future perhaps the necessities of life (and these "necessities" will be far more inclusive than those we know today) will be made by the automatic factory. The luxuries—and everyone will be able to afford at least some luxuries—will be hand crafted (in well-equipped shops) in small quantities. Thus, the optimum "big" will be complemented by the valuable "small."

There's nothing wrong with this that I can see. ■

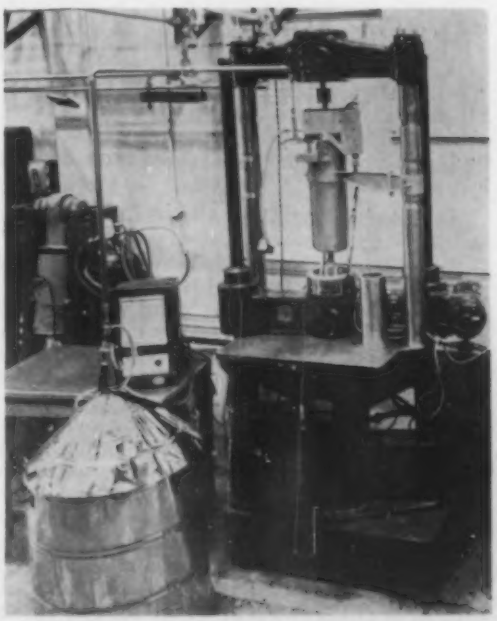
TENSILE TESTS AT –450 F

■ Standard tensile-test specimens, 0.252 in. dia, are held in a cryostat mounted in a standard testing machine, for making tensile tests down to liquid-helium temperatures. Equipment was developed by A D Little Inc, for the Watertown Arsenal Laboratories. The cryostat is a double-wall vacuum-insulated chamber, cooled by helium supplied from a storage chamber when an exhaust line from the cryostat is opened by a solenoid.

Four copper-constantan thermocouples in series, each in contact with the specimen, sense temperature and feed a potentiometer controller. Temperature is dropped by opening the exhaust line from the cryostat, which bleeds liquid helium into the chamber; when the exhaust line is closed, radiation slowly raises the specimen temperature.

Strain is measured across the diameter of the specimen by four feeler fingers making contact at 90° around a diameter. The fingers are driven along the length of the specimen by a scanning motor to find the minimum diameter, and thus measure necking when it occurs. Fingers are pivoted in diaphragms that seal the cold chamber; other end drives differential transformers that sense displacement and measure diameter.

In operation, the specimen is first brought to desired temperature, and load is then applied at a constant rate. Stress and strain are recorded, while temperature is held constant. Preliminary tests have been made on stainless, titanium, copper and aluminum—promising much useful design data for cryogenic service. ■



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ALCOA ALUMINUM

SCREW MACHINE STOCK

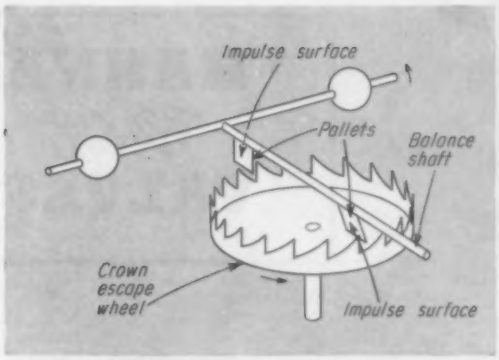
6 Escapement Mechanisms

FEDERICO STRASSER, *Mankowitz & Strasser*
Santiago, Chile

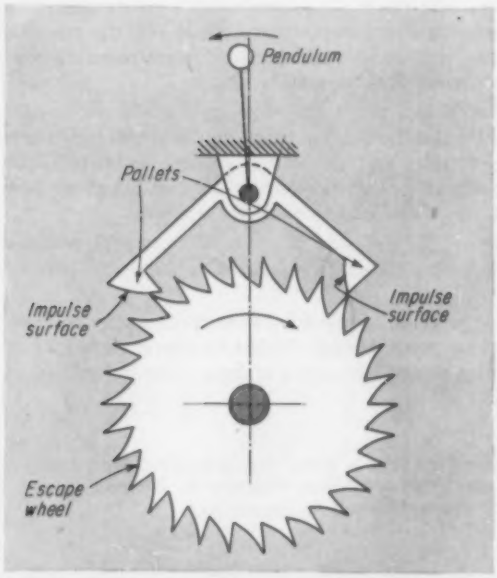
Escapements, a familiar part of watches and clocks, can also be put to work in various control devices, and for the same purpose—to interrupt the motion of a gear train at regular intervals.

Each escapement shown here contains an energy absorber. Whether balance wheel or pendulum, it allows the gear train to advance one tooth at a time, locking the wheel momentarily after each half-cycle. Energy from the escape wheel is transferred to the escapement by the advancing teeth, which push against the locking surfaces (pallets).

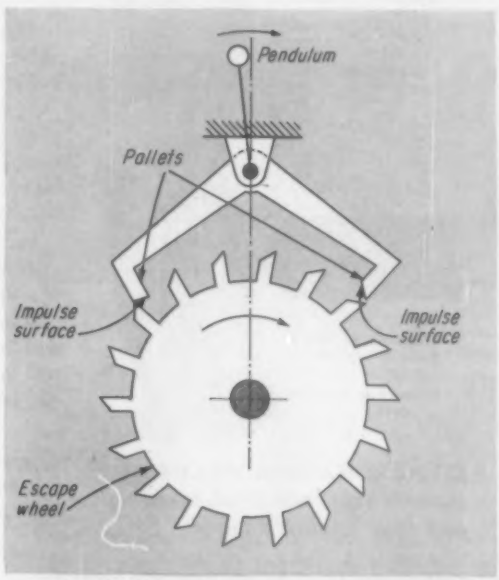
Seven more escapement systems will be illustrated in a forthcoming issue.



1 VERGE. Pallets are alternately lifted and cleared by diametrically opposed teeth on escape wheel, thus rocking balance shaft. One pallet or the other is always in contact with a tooth of the escape wheel.



2 ANCHOR—RECOIL. As pendulum swings to one side, pallet engages tooth of escape wheel. When wheel is gripped, it recoils slightly. Pendulum starts in opposite direction by push of wheel transmitted through pallet. As pendulum swings to other side, the other pallet engages escape-wheel tooth, recoils, and repeats cycle.



3 ANCHOR—DEAD BEAT. For greater accuracy, recoil escapement is modified by changing angle of impulse surfaces of pallets and teeth so that recoil is eliminated. The teeth of escape wheel fall "dead" upon pallets; as pendulum completes its swing, escape wheel does not turn backward.

continued on page 67

. . . MICROMETER SETTING

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½", ¾"
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Sizes ¼", ⅜",
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FOR AIR • OIL • WATER • OTHER FLUIDS

REGULATING cylinder speeds or controlling fluid flow of air, oil or water is so simple with Hanna Flo-Set Valves . . . you need only turn the valve body one revolution to adjust from zero to full pipe capacity. Micrometer-type graduations are numbered to indicate the percentage of pipe capacity. Once set, the position can be locked to avoid accidental change. Future resetting to a predetermined flow requires no guesswork.

Hanna Flo-Set Valves allow full flow in one direction—controlled flow in the opposite. Used in pairs, they regulate independently cylinder instroke and outstroke speeds. Hanna Flo-Set Valves assure uniform speed, smoother action and improved performance of cushioned and non-cushioned cylinders.

Valve sizes are ¼", ⅜", ½", and ¾" . . . a ¼" Jr. model, without graduations or locking collar, is available for light piping and tubing.

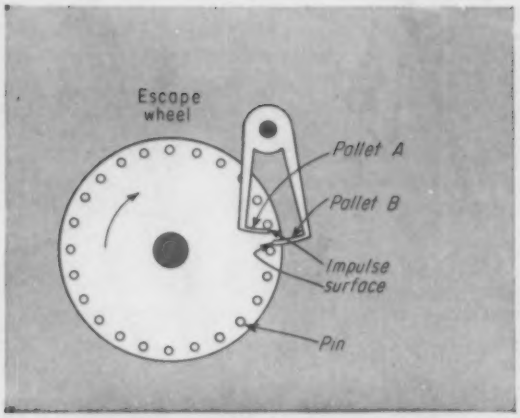
Whatever your problem of precision fluid control may be—you will find the best answer in Hanna Flo-Set Valves—designed, built and guaranteed by Hanna's 50 years of experience in hydraulics and pneumatics.

WRITE FOR LITERATURE AND COMPLETE DETAILS,
or consult your classified telephone directory or Thomas' Register for your nearest Hanna representative.

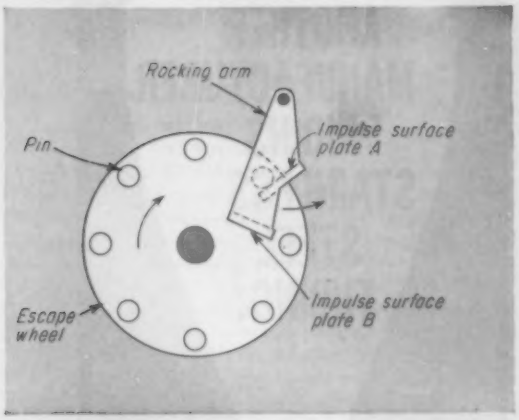
Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

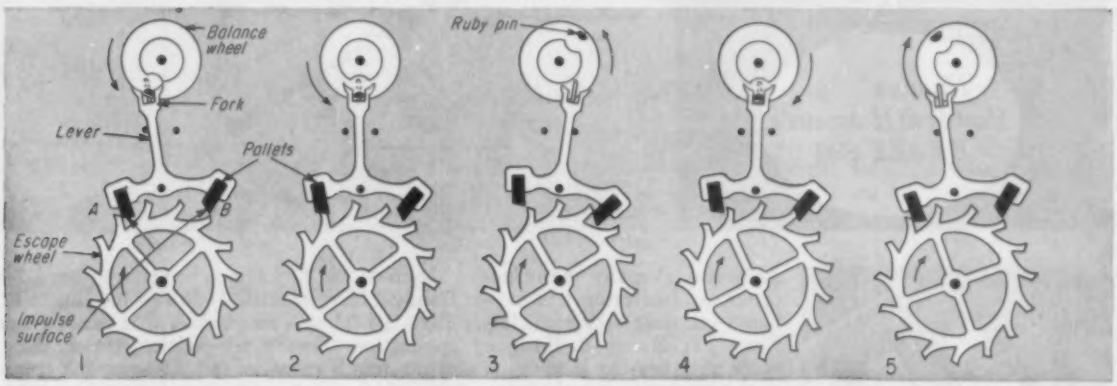
1751 Elston Avenue • Chicago 22, Illinois



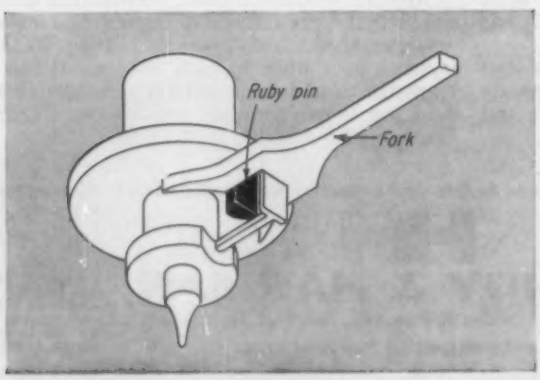
4 PIN WHEEL. Pallet *A* is about to unlock escape wheel. Pin will give a push to pallet *A* while sliding down impulse surface. As pendulum continues to swing, pallet *B* will stop pin, thus locking escape wheel. After pendulum reverses direction and swings toward dead center, pallet *B* releases wheel and receives an impulse from pin.



5 LANTERN WHEEL. Escape wheel is stopped when pin hits plate *A* of pallet, attached to rocking arm. As arm swings to right, pin pushes against impulse surface of plate until pin is clear. Escape wheel then turns freely until pin is stopped by plate *B* of pallet. Arm starts back toward left, receiving impulse from pin until latter clears plate.

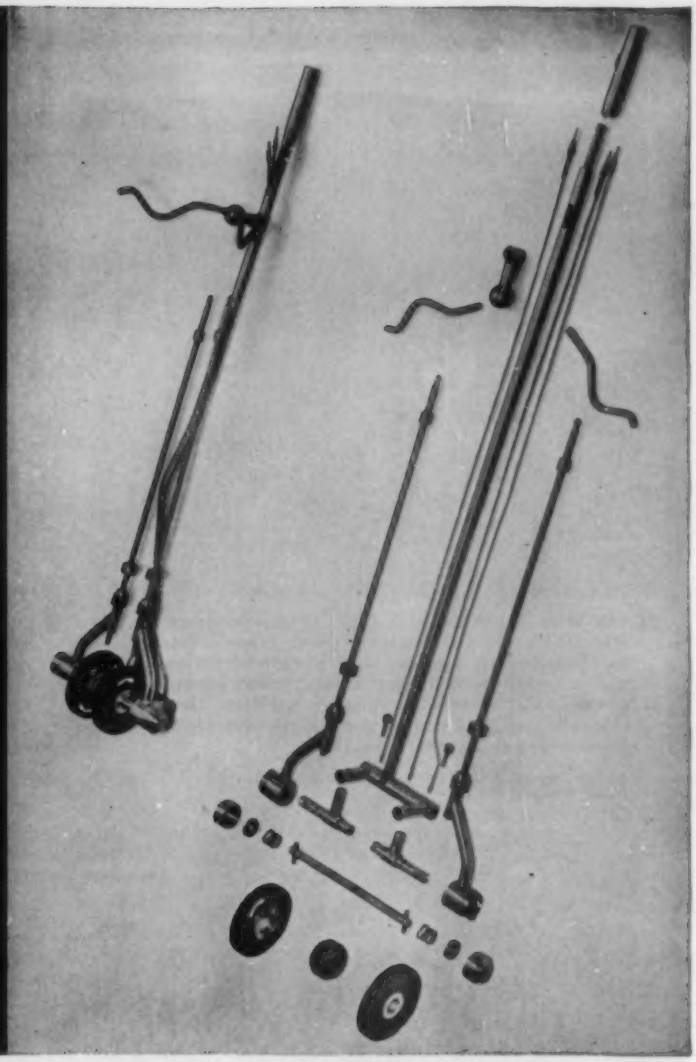


6 MUDGE'S LEVER. As balance wheel swings counterclockwise (1), the ruby pin enters fork of lever and pushes it to the right. The lever releases tooth of escape wheel, which starts turning and gives a tiny push (2) to impulse surface of pallet A. This is transmitted to balance wheel through fork and ruby pin. Balance wheel continues rotating counterclockwise (3) while lever swings to right and pallet *B* stops the escape wheel by engaging tooth. When balance wheel reaches its hairspring's limit, it reverses direction and re-enters fork (4). Ruby pin pushes lever to left, and receives impulse when escape wheel starts to move. Balance wheel continues clockwise until it reaches opposite limit of its hairspring. Lever continues moving to left until it again stops escape wheel (5) and awaits return of ruby pin. Another view of Mudge's lever is given in (6). This escapement is very precise because of the small portion of each half-cycle that escape wheel and balance wheel are in contact. Friction drag is at a minimum.



HERE'S HOW STILL ANOTHER MANUFACTURER JOINS STAINLESS STEEL TUBING:

He uses Handy & Harman's BRAZE 630



He's one of many manufacturers and fabricators who have found—to their lasting satisfaction—that Handy & Harman silver alloy brazing is the final answer to stainless steel joining problems.

Super-Donic Manufacturing Company, Atlanta, Georgia, manufactures "Dual Arm Transmissions" for the dental industry. Most everybody has—at one time or another—seen and/or felt this unit in operation.

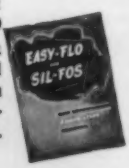
It is fabricated of small diameter 304 and 316 stainless steel tubing and, in its assembled form, consists of some 17 separate brazed joints. Joints must be strong, corrosion resistant and neat-appearing.

Each of the 17 joints is hand-torch brazed with Handy & Harman BRAZE 630 wire and HANDY FLUX TYPE B-1. There's no question that this is a unique application. There's no question, either, that the application is stainless steel. The ease and economy with which this manufacturer solves his problems can be just as readily applied to *your* stainless steel joining problems.

Strength, production speed, electrical and thermal conductivity, gas and liquid tightness and low cost are *natural* benefits of silver alloy brazing. We think it worth your while to learn more about this remarkable metal-joining method—we'll be glad to send you any information you ask for. Handy & Harman, 82 Fulton St., New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits . . . includes details on alloys, heating methods, joint design and production techniques. Write for your copy.



Your No. 1 Source of Supply and Authority on Brazing Alloys

HH

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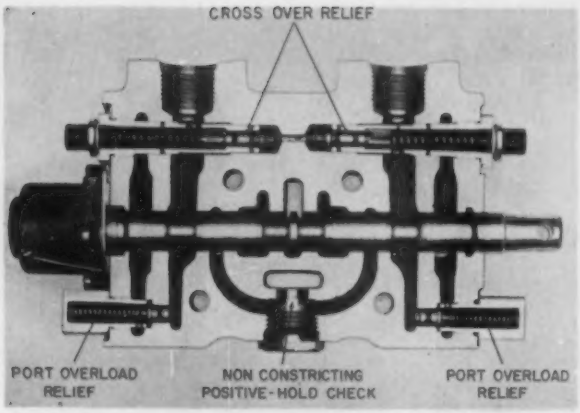
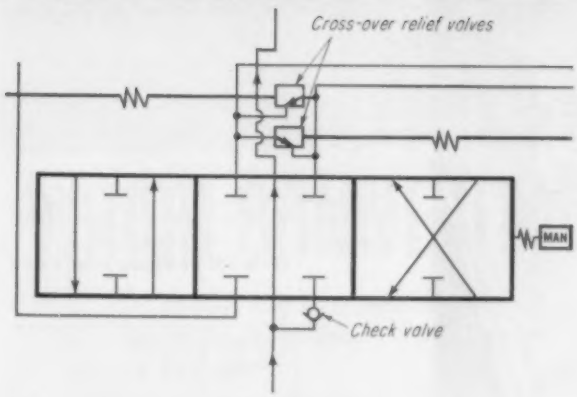
SIGNIFICANT COMPONENTS MATERIALS, PROCESSES





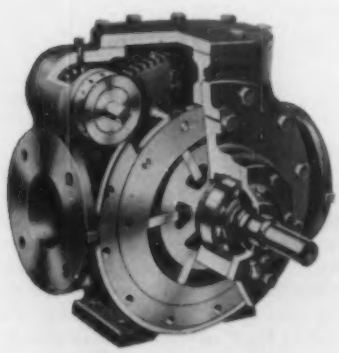
Parallel-circuit, directional-control valves . . .

are said to improve back-pressure characteristics by 50% and to increase system efficiency over company's previous line of valves. Through-passages have been enlarged, land dimensions reduced, and sharp angles in flow passages eliminated. Valves have nominal ratings of 20 and 35 gpm, and 2000-psi system pressure. High degree of flow metering results from exponential-curve edges on spool lands. Working sections in line provide basic directional control functions in single- and double-acting, three- and four-way, three-position units; double-acting float, four-way, four- and five-position models; and double-acting regenerative, four-way, four-position type. Available with spool-action, spring-return to neutral or detent-position, requiring manual return to neutral. In addition to primary function as directional-control valves, line also offers crossover relief valves (one or two), overload-port relief valves, pilot-operated port checks, anticavitation checks, and flow-restrictor checks; all of which can be built into working section. All models continue to provide no-load holding check feature. Said to be same price as company's TB line. Delivery, about 3 to 4 wk. **Commercial Shearing & Stamping Co, Youngstown, Ohio.**

Circle 300 on Reader Service Card

Variable-capacity rotary pumps . . .

control variations in flow instantly by graduated dial, which can be turned manually or automatically. Flow rates from zero to full capacity can be dialed without changing pump speed. Dial operates pinion and rack to rotate pump liner to vary amount of liquid flow. Pump can be powered with any standard-speed motor. Flow can also be reversed while in operation by dialing. Currently offered in 2-, 3- and 4-in. sizes to provide capacities up to 450 gpm. Handle liquids up to 85,000 SSU and operate at max differential pressure of 100 psi. Four pumps are offered in each of three sizes. Two are of external, ballbearing type, with mechanical seals; two are packing-gland pumps for higher temperatures and viscosities. Pumps are particularly suited for applications where change in flow rate is required to meet varying delivery conditions; where change in flow rate is necessary to meet varying liquid condition, such as viscosity; for liquid proportioning, where one or more units are combined into system. **Blackmer Pump Co, Grand Rapids 9, Mich.**



Circle 301 on Reader Service Card

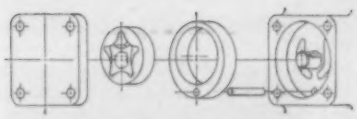
Elastic, flexible wire . . .

in single and multiple conductors, with up to six conductors per cable, elongates to 300% in most types. Basically, commercial types consist of rubber or rubber-like core, braided with conductor material and insulated with nylon braids. Conductor material is usually 99% copper, 1% cadmium. Unlike wires that depend upon coils or spirals for stretchability, this wire is straight, even when relaxed. One type is said to have elongation life of about 100,000 cycles. Available in variety of colors and in lengths from 1 in. to 1 mile. Five varieties are offered from stock. Stock commercial types are rated for resistances of about 2/10, 1 and 4 ohm per ft; military types for resistances of about 2/10 and 1 ohm per ft. Military varieties have silicon-rubber core. Operate in temperatures of −85 to 185 F. Commercial types operate in temperatures of −13 to 185 F. Complete assemblies are available, incorporating special terminations, molded parts and custom mechanical configurations. Suitable for movable parts that require electricity. **National Radio Co Inc, 37 Washington St, Melrose 76, Mass.**

Circle 302 on Reader Service Card

Air-damping dashpot . . .
can be used to control system-stabilization, vibration-damping and time-delay. Unit, constructed of graphitized carbon piston and low-expansion glass cylinder, weighs less than 1 oz. These are ground and fitted to tolerances of 0.0001 in. Standard dashpot provides equal damping in two directions, useful where application does not require fast reset time. Other models are capable of one-way damping. In each case, damping is adjustable with screwdriver or can be factory-set. Once set, calibration is reported to be maintained throughout millions of cycles under adverse conditions of temperature, humidity, shock and corrosive atmosphere. **Electric Regulator Corp, Pearl St, Norwalk, Conn.**

Circle 303 on Reader Service Card



Three pumping elements . . .
that can be built into housing of any mechanism requiring a pumping function are said to eliminate purchase of complete pumps. In principle, a gear pump, inner and outer rotating elements, and eccentric locator-ring become complete pump by through-boring casting or frame of mechanism to accommodate OD of locator-ring and by providing porting. Handles variety of fluids at rates up to 100 gpm and pressures up to 1000 psi. Positive-displacement pump delivers predetermined amount of fluid in direct proportion to speed. **W H Nichols Co, Waltham, Mass.**

Circle 304 on Reader Service Card

Solenoid-operated valve . . .
can be used for metering, sampling or on-off control in applications involving corrosive fluids, slurries, dry powder or sanitary products. Said to be capable of gastight shutoff under vacuum or pressure conditions. Valve consists of rubber body that is pinched closed by spring-loaded solenoid mechanism. There are no moving parts in fluid stream and no seats, disks or packing glands. Normally closed, energized-to-open valve can be operated manually or from programers, alarms, timers or automatic sensing instruments. Standard bodies have max pressure rating of up to 50 psi for smallest size. Standard max temperature rating is 180 F. Available in sizes from 1/16 to 1 in. Weighs 4.5 lb. Measures 2½ x 7¼ x 3¼ in. ID of bodies correspond to OD of standard metal tubing within this range. **RKL Controls Inc, Hainesport Industrial Park, Hainesport, NJ.**

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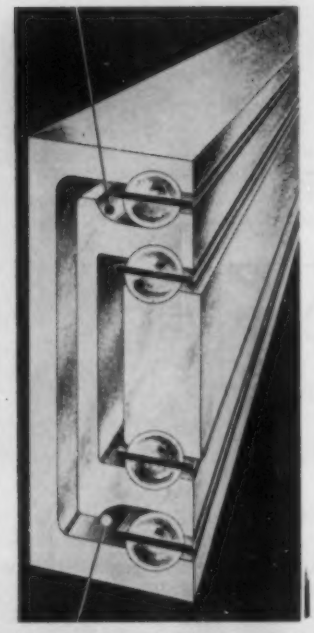
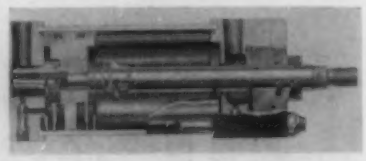


Self-aligning slides . . .
automatically adjust to fit misaligned chassis and cabinets. Self-aligning flat-groove slide is said to eliminate need to shim. Meet military specifications for material and finish. Load ratings are same as those for regular slides produced by Grant. **Grant Pulley & Hardware Corp, High St, W Nyack, NY.**

Circle 306 on Reader Service Card

Miniature mercury switch . . .
is ½ in. long max and 0.162 in. dia. Has $\frac{1}{10}$-amp rating. Switching action is SPST; differential angle is 15°. Ac and dc load at 115 v and 230 v is 0.1 amp. Although initially developed as reversing switch for motor clutch in portable device, miniature switch is suited for such applications as miniature on-off switch, paging devices, switching requiring slight force, or applications that have low-load, lightweight or space factor. **Gordos Corp, 250 Glenwood Ave, Bloomfield, NJ.**

Circle 307 on Reader Service Card



Square-end double cylinders
for hydraulic and pneumatic service have two-stage cushion that is said to achieve smooth deceleration of piston. Dimensionally interchangeable cylinders are reported to meet JIC recommendations. Desired amount of cushioning is attainable by turning adjusting needle valve. Full floating cushion makes possible rapid and smooth advance of piston rod without use of ball check. Available in bore sizes of 1½, 2, 2½, 3½, 4, 5, and 6 in. For air service, max pressure is to 250 psi for all bores. For oil service, to 1000 psi through 3½-in. bore; to 700 psi through 5-in. bore; to 600 psi on 6-in. bore. Thirteen mounting styles are offered. Air models are rated for temperatures to 212 F; oil models to 250 F. **Mead Specialties Co, Dept SH-44, 4114 N Knox Ave, Chicago 41.**

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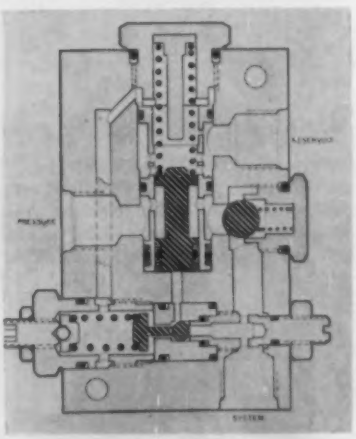
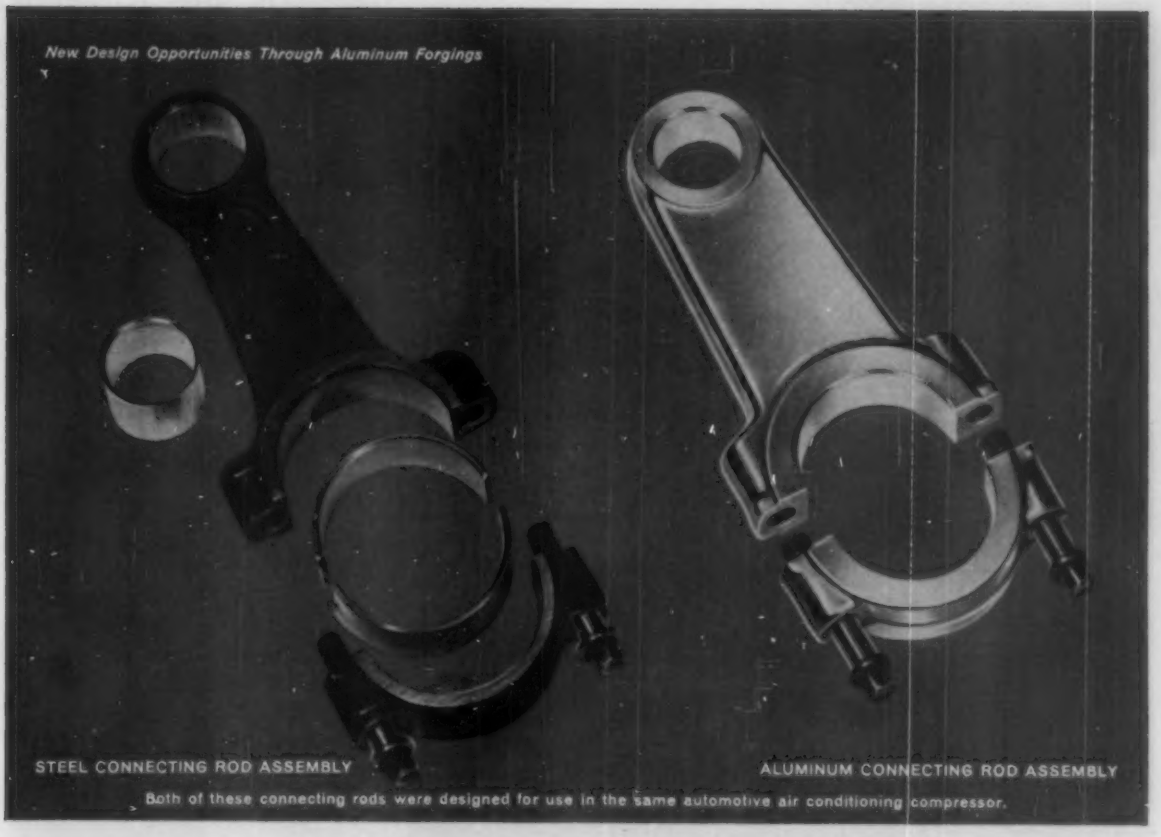


Adjustable unloading valve . . .
diverts full pump to reservoir automatically when system pressure reaches preset point. Used in accumulator and high-low circuits or for venting large relief valves, valve offers 5 to 20% adjustable differential between load and unload pressures, and sliding spool that will not stop half-way. Has built-in check valve and internal pilot that

continued on page 72

New Design Opportunities Through Aluminum Forgings



STEEL CONNECTING ROD ASSEMBLY

ALUMINUM CONNECTING ROD ASSEMBLY

Both of these connecting rods were designed for use in the same automotive air conditioning compressor.

WHICH CONNECTING ROD COSTS LESS?

One glance tells you it's the aluminum connecting rod at the right. Two pieces are easier and less expensive to fabricate than five.

By designing this connecting rod as a Kaiser Aluminum forging, Lennox Tool & Machine Builders of Lima, Ohio, cut costs for their customer, Airtemp Division, Chrysler Corporation.

The steel connecting rod formerly used required five different pieces, including three bronze inserts for wrist pin and crankshaft bearings, plus two connecting rod bolts. Plenty of precision machining was also required.

The new aluminum connecting rod consists of only two pieces, plus the two connecting rod bolts. For this part, the forging itself was bored to provide a hard mirror-finish surface for wrist pin and crankshaft bearings, thus eliminating the three bronze inserts.

Strength? The aluminum forging meets every strength and dimensional stability requirement specified for the compressor application. In fact, the life expectancy of forged aluminum rods and steel rods with bronze insert is virtually the same!

This is another example of how strong, lightweight Kaiser Aluminum forgings can simplify design and cut material, machining and assembly costs. To find out how Kaiser Aluminum forgings can save you money, mail the coupon now!

KAISER ALUMINUM

THE BRIGHT STAR OF METALS

*TRADEMARK KAISER ALUMINUM & CHEMICAL CORP.

Kaiser Aluminum & Chemical Sales, Inc.
Dept. FO-124P, Kaiser Center
300 Lakeside Drive, Oakland 12, Calif.

Please send me the latest aluminum forgings design packet describing the many advantages of aluminum forgings for commercial use.

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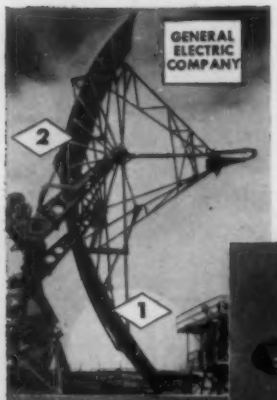
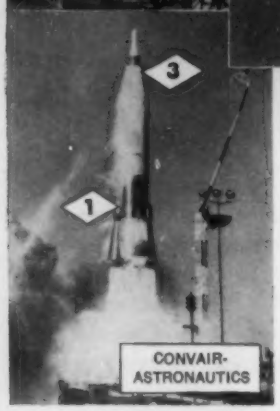
CIRCLE 71 ON READER SERVICE CARD

for protection on light metals

you need IRIDITE®

PROCESS ENGINEERED
CHROMATE CONVERSION COATINGS





1 Iridite protects against high altitude weather extremes and against corrosion by hydrocarbon fuels, such as gasoline and kerosene.

2 Iridite provides a highly protective non-porous paint base.

3 Iridite protects against corrosive storage conditions.

And, Iridite gives you these additional advantages:

ON ALUMINUM—needs only normal precleaning. Film withstands cold forming or bending. Easily heliarc welded. Unusually low electrical resistance. Clear, yellow or dye-colored finishes.

ON MAGNESIUM—short immersion, room temperature solution, no electrical equipment. Corrosion protection relatively unaffected by high drying temperatures. Applicable to all alloys. Low electrical resistance. Color ranges from light gray to dark brown.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Easily applied at room temperatures with short immersion, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel; special equipment, exhaust systems or highly trained personnel not required.

For complete information on Iridite, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILES.

Iridite is approved under government and industrial specifications.

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Chemical and Electrochemical Processes, Anodes, Rectifiers, Equipment and Supplies for Metal Finishing

IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

eliminates extra piping. Rated for 800 to 3000 psi unload pressure range and max pilot pressure up to 5000 psi. Measures 5 x 4½ x 1½ in. Available from stock with ½-in. SAE ports. **Fluid Controls Inc, Box 186, Mentor, Ohio.**

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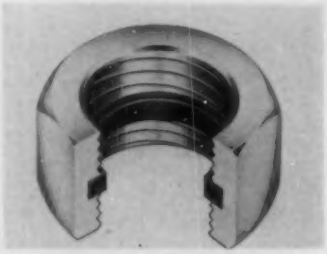


Reversible, self-locking nut

has internal locking ring that can be used either side up for automatic assembly. For standard applications, fastener is made with internal locking ring of Delrin or polypropylene, both of which are flexible, resilient materials. For high-temperatures, nut is made with internal, spring-steel locking ring. To be available in Sept in all standard and commercial sizes. **Jacobson Nut Mfg Corp, Box 177, Kenilworth, NJ.**

Circle 310 on Reader Service Card

Aluminum-covered wire and strand . . .

is produced by controlled atomic-weld process that achieves a ductile and permanent weld between steel core and thick cladding of pure aluminum. Cladding metal is applied in powdered form to core, while latter is being moved under tension, compacting cladding metal. Compared with solid aluminum wire, it has equal life, one-third conductivity and eight times the strength. Compared to steel wire, it has same high tensile strength, but furnishes higher conductance and is said to last longer. **Copperweld Steel Co, Pittsburgh 19.**

Circle 311 on Reader Service Card

Controlled-voltage device . . .

incorporated into circuit using linear variable differential transformers, can be used as zero adjust or for zero suppression of all or part of primary signal. Sections or portions of input signal can thereby be expanded to read full scale. Instrument may also be used as control-point-setting device, calibrated to operate at any desired value of input variable and as null-balance device in conjunction with vacuum-tube voltmeter to make simple manual null-balance measuring system. Micrometer reference transformer consists of

continued on page 76

With Extras . . . At No Extra Cost

1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
2. NEW "SUPER" CUSHION for air or METALLIC SELF-ALIGNING MASTER CUSHION for oil.
3. HARD CHROME PLATED CYLINDER BORES AND PISTON RODS for greater protection and reduced wear.
4. ONE PIECE PISTON assures better alignment, longer bearing and packing life.
5. FORGED SOLID STEEL HEADS throughout entire line.
6. PILOTED PACKING GLAND with extra long bearing for additional strength and support to piston rod.
7. NO TIE-RODS TO STRETCH—gives you 360° port rotation . . . less space used . . . full strength.
8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

Specify the

T-J Spacemaker

for longer, more efficient cylinder service

You too—can reduce replacement expenditures—lower maintenance costs with the T-J Spacemaker cylinder line. Designed and engineered for ruggedness, and accuracy of operation, the Spacemaker assures longer, uninterrupted operation.

The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

T-J TOMKINS-JOHNSON
RIVITORS . . . AIR AND HYDRAULIC CYLINDERS . . . CUTTERS . . . CLINCHORS

CIRCLE 73 ON READER SERVICE CARD 73

THESE 13 SPECIAL ALLOYS FROM *can help you solve design problems . . .*

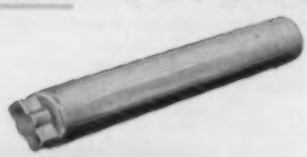
As the result of the knowledge gained over the years by working closely with hundreds of customers in helping solve innumerable design and production problems, the Mueller Brass Co. has developed a series of special alloys for use in tough or unusual applications.

This group of special alloys, each having distinct characteristics and advantages, are available in rod form in many sizes and shapes as well as forgings.

CHARACTERISTICS AND APPLICATIONS	ALLOY NO.	NAME	TEMPER
TUF-STUF® ALUMINUM BRONZES AND NICKEL ALUMINUM BRONZES have great strength characteristics. All are more resistant to corrosion cracking under load than copper-zinc alloys and, in addition, some are heat-treatable. They can withstand heavy pounding and have proved excellent for such parts as gibs, cams, valve seat inserts, shifting forks and propeller hub cones.	224E-30	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 165
	224E-75	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 175
	224C	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 185
	224H	"Tuf-Stuf" Aluminum Bronze	BRINELL 1000 KG load 200
	224K	"Tuf-Stuf" Nickel Aluminum Bronze	BRINELL 3000 KG load 250
ALUMINUM SILICON BRONZE is free turning; has high strength, is corrosion resistant and non-magnetic and resistant to corrosion cracking under load.	802	Aluminum Silicon Bronze	ROCKWELL-B 75
600 SERIES® FORGEABLE BEARING ALLOYS range from high strength to low loaded ductile. All are corrosion resistant, free cutting, can be used with hard or soft mating members and can be soldered. They are employed in a great variety of applications ranging from pump gears and valve stems to pinion shafts and transmission rings.	600	Forgeable Bearing Alloy	ROCKWELL-B 88
	601	Forgeable Bearing Alloy	ROCKWELL-B 87
	602	Leaded Forgeable Bearing Alloy	ROCKWELL-B 87
	604	High Leaded Forgeable Bearing Alloy	ROCKWELL-B 86
	605	Low Leaded Forgeable Bearing Alloy	ROCKWELL-B 80
MANGANESE BRONZE ALLOYS are exceptionally strong, tough, resistant to shock and corrosion. Good for screw machine products and forgings for aircraft parts.	241A	Manganese Bronze A	ROCKWELL-B 85
	721	Manganese Bronze High Tensile Grade B	BRINELL 1000 KG load 200
TELLURIUM COPPER has very high electrical and thermal conductivity combined with good corrosion resistance and machinability. Excellent for electronic components.	799	Tellurium Copper	ROCKWELL-B 45

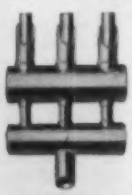
NOTE: The values shown are average values normally obtained in production. Variations must be expected in practice. The values should be used as a general guide rather than the basis for specifications.

ONE DEPENDABLE SOURCE FOR



COLD-PREST® IMPACT EXTRUSIONS

SINTEEL® POWDERED METAL PARTS



FORMED COPPER TUBE

MUELLER BRASS CO.

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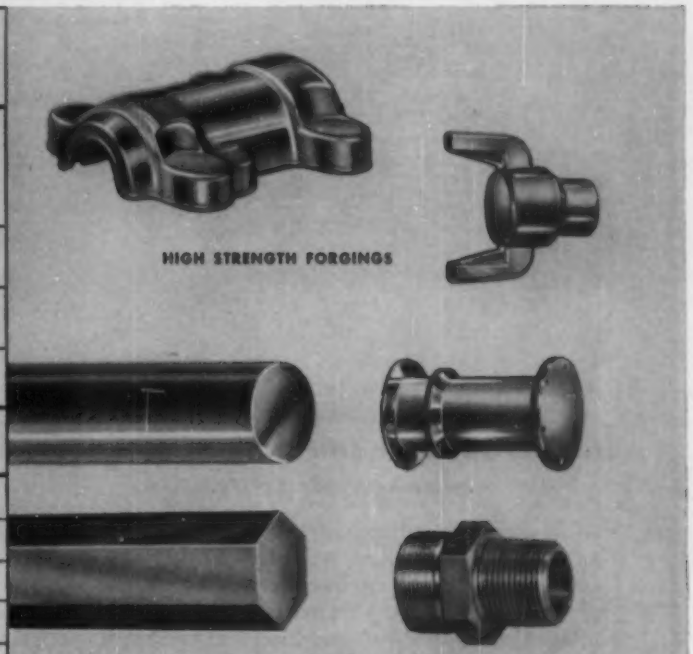
lower costs and improve your products

Mueller Brass Co. engineers and metallurgists are always ready to assist in the selection of the proper alloy for your particular product.

Regardless of your responsibility... design, specification, production or purchasing... Mueller Brass Co. special alloys can help you lower costs and improve your products. Call the "Man From Mueller Brass Co." today and put these remarkable alloys to work on your toughest jobs.

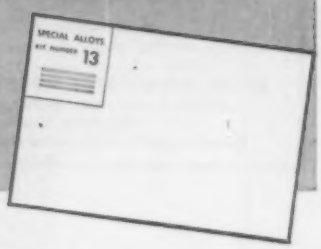
Yield Strength at 0.5% Extension Lbs./Sq. In.	Tensile Strength Lbs./Sq. In.	Relative Machinability Free Cutting Brass=100%
50,000	82,000	30
65,000	100,000	30
62,000	95,000	35
70,000	90,000	30
65,000	105,000	20
35,000	85,000	60
60,000	90,000	25
55,000	78,000	35
65,000	85,000	65
55,000	75,000	80
45,000	70,000	55
55,000	78,000	25
68,000	115,000	35
40,000	43,000	90



HIGH STRENGTH FORGINGS

ROD SHAPES FOR SCREW MACHINE PRODUCTS

For further information on these alloys write today for Special Alloys Kit No. 13. Engineering information on other fabricated products is also available... please specify the manual you desire.



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CUSTOM EXTRUDED PLASTIC SHAPES AND INJECTION MOLDINGS

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

PORT HURON 29, MICHIGAN

301

CIRCLE 75 ON READER SERVICE CARD 75

Paralyzing, deadly cold — yet Allen safeguards men and machines in a warm blanket of protection

Allen complete winterization systems, custom-made for any type of equipment, will meet all military specifications. Weather-wise engineers can work out the solution to the toughest way-below-zero problems — assuring prompt starts, efficient operation and personnel comfort.

Ask us to submit a field-tested system for your product.

ALLEN INDUSTRIAL PRODUCTS, INC.
Affiliate of Stolper Steel Products Corporation
354 Pilgrim Road
Menomonee Falls (Milwaukee District), Wisconsin

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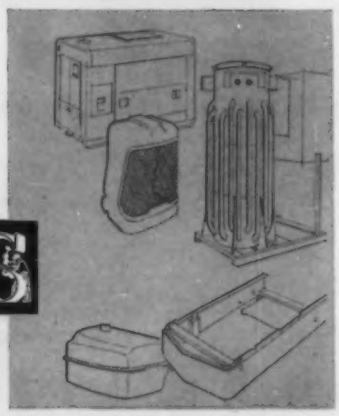

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You save money and time by having Stolper produce your sheet metal parts and assemblies. Without capital investment, you can employ diversified facilities — creative design, ingenious engineering, reliable production. See for yourself — write soon.

STOLPER STEEL PRODUCTS CORPORATION
306 Pilgrim Road
MENOMONEE FALLS (Milwaukee District), WISCONSIN

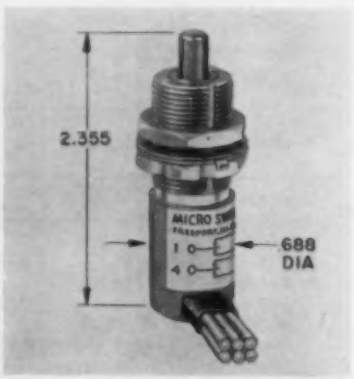
aluminum frame and micrometer anvil rod to which is mounted core of linear variable-differential transformer. Units include necessary dial for indication of shaft position and transformer adjustment. Operates at up to 200 F. Has resolution of 0.000,25 in. **Schaevitz Engineering, Rt 130 at Schaevitz Blvd, Pennsauken, NJ.**

Circle 312 on Reader Service Card

Miniature speed control . . .

contains solid-state amplifier, servomotor, gear train and potentiometer-switch combination that is ½ in. long. Package measures 1½ x 1½ x 3 in. Pot has four electrically isolated wipers spaced 90° apart, all contacting same coil. Switch has four wipers riding on alternately conducting and nonconducting surface. Speed is directly proportional to dc signals. **Spectrol Electronics Corp, 1704 S Del Mar Ave, San Gabriel, Calif.**

Circle 313 on Reader Service Card



Sealed subminiature switch . . .

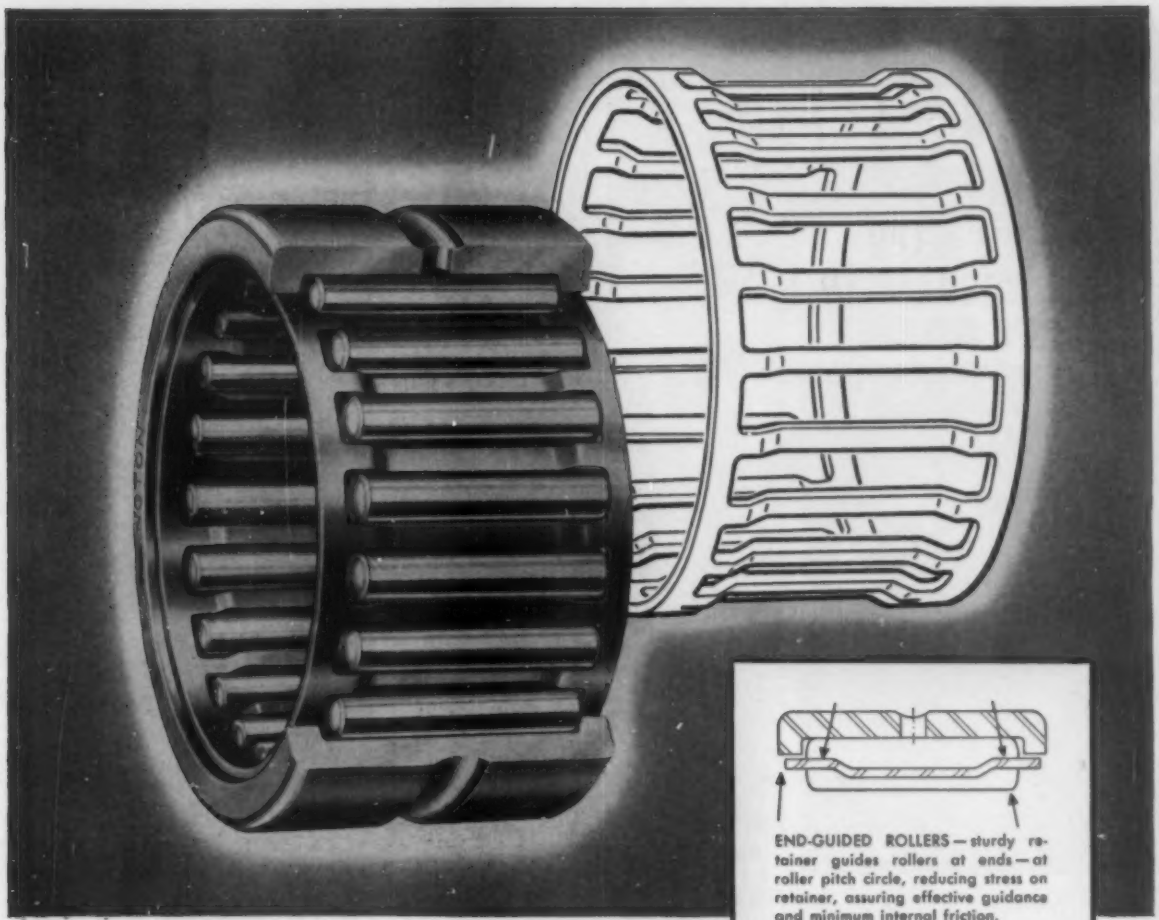
operates in temperatures of —65 to 250 F. SPDT switching unit is housed in sealed enclosure that has been evacuated and filled with inert gas. O-ring seal on actuator shaft, glass-to-metal terminal seals and potted leadwire termination keep dust, moisture or air out of switching chamber. Ice-scraper ring removes ice or mud from actuator shaft. Plunger actuator or rotary linkage-lever actuator designs are available. Electrical rating at 28 v dc is 24 amp inrush, 7 amp resistive. Dimensions of plunger switch housing are 2.355 x 0.688 in. dia. Weighs 2.5 oz without leadwires. **Micro Switch, Freeport, Ill.**

Circle 314 on Reader Service Card

Linear displacement transducers . . .

provide electrical measurement of mechanical phenomena with min transducer size and weight. Based on differential-trans-

continued on page 78



The New Torrington Heavy Duty Roller Bearing

Key to Long Life... Roller Guidance Where It Counts!

This sturdy flange-riding retainer in Torrington Heavy Duty Roller Bearings insures the highest degree of roller guidance where it's most effective... at the roller ends along the pitch circle. You get outstanding service life through minimum internal friction, high roller stability and efficient lubrication.

Controlled contour rollers prevent high end-stress concentrations. Careful heat treatment of the channel-shaped outer race insures high shock resistance. The Heavy Duty Roller Bearing has proved successful under unusual conditions of deflection or misalignment. Torrington Heavy Duty Roller Bearings are giving longer life in such difficult applications as two-cycle engines, hydraulic pumps, oil-field equipment, sheaves and transmissions. For design and application assistance on the Heavy Duty Roller Bearing—and every basic type of anti-friction bearing—call your Torrington District Engineer.

END-GUIDED ROLLERS—sturdy retainer guides rollers at ends—at roller pitch circle, reducing stress on retainer, assuring effective guidance and minimum internal friction.

UNIFORM LOADING—Torrington controlled contour rollers eliminate stress concentration at roller ends. End-stress pattern of unrelieved cylindrical rollers is shown in black outline. Area in gray shows uniform loading over entire contact length of Torrington rollers.

AMPLE LUBRICANT STORAGE AREA is provided by the retainer design, which also allows unrestricted flow of lubricant within the bearing.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

CURTIS HELPS THIS SWITCH LIVE TO A RIPE OLD AGE

Pad-mounted transformers for underground power distribution systems are built to last a lifetime. They require a minimum of maintenance. Settings are changed infrequently. But when a change is required, this switch must operate smoothly and surely. To insure a long, dependable life, without freeze-ups or rust-outs, the manufacturer equipped it with a Curtis C-646 1" O.D. Stainless Steel double universal joint.

This kind of dependability is the stock-in-trade of Curtis joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, continuous testing, inspection and quality control at every stage of manufacture — these are some of the things that make Curtis joints your most dependable buy.

14 SIZES ALWAYS IN STOCK
3/8" to 4"

Not sold through distributors. Write or phone REpublic 7-0281 for latest catalog, free engineering data and price list.

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UNIVERSAL JOINT CO., INC.

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As near to you as your telephone. Exclusively a manufacturer of universal joints since 1919

former principle, units offer resolution to 0.5 micron, linear ranges to ±0.1 in., and are reported to avoid wear and noise problems of potentiometer-type transducers. Output is 3 milliv per 0.001 in. per v of excitation. Measures 1¾ x ¼ in. dia. Linearity is said to be 0.25%. Price is $120. Daytronic Corp, 225 S Jefferson St, Dayton 2, Ohio.

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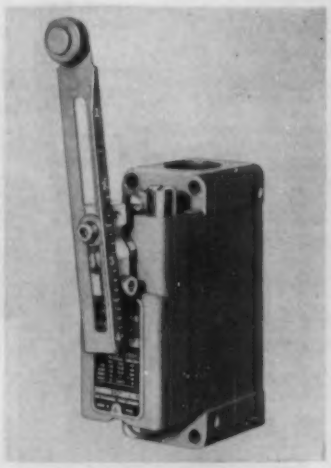

Adjustable roller arm . . .

on Type AW limit switches can be adjusted to any length between 1 and 4 in. Arm length can be changed by loosening allen-head screw and sliding arm up or down. Scale on side of arm is marked in ¼-in. increments. Roller can be turned to inside or outside of arm and roller dia of ¾ and 1 in. are available. Square D Co, 4041 N Richards St, Milwaukee 12.

Circle 316 on Reader Service Card

Midget solenoid valve . . .

provides automatic control of small flows of water or air. Available in wide range of voltages and solenoid types, valve is offered in angle or straight pattern. Operates over range of working pressures to 150 psi. Automatic Controls Div, Hays Mfg Co, 805 W 12th St, Erie, Penna.

Circle 317 on Reader Service Card

Silicon power rectifier . . .

employing solid-stack construction, is said to deliver up to 900 amp in full-wave circuits. Solid-stack assembly is said to provide constant pressure between silicon cells and copper fins, minimizing local heating effects and providing optimum heat transfer. Operates at up to 302 F ambient. Assemblies are available for either forced or natural convection cooling and can be coated with multiple paint finish for oper-

continued on page 79

How to improve equipment designs

Above, O. C. White Model G2MC incandescent fixture with Kohlgard hot lamp protector. Ultra-flex arms permit moving light to any position.

Below, Stocker & Yale Sealed Fluorescent Unit SP-24. Provides complete protection against dust, oil, etc. Easily wiped clean.

. . . Add a supplementary light and you might well have the answer

Proper illumination of work areas is a necessity if operators are to get the most out of equipment. Stocker & Yale and O. C. White supplementary lights give the illumination they need . . . clear, concentrated, high level, glare-free. And, too, these lights add a profitable selling feature at very little extra cost.

There's a Stocker & Yale or O. C. White Light just right for every requirement: standard or special • fluorescent or incandescent • choice of arms, bases, switches, ballasts, reflectors • available with optically ground magnifiers • sealed units for protection against dust, oil, etc. • arms easily adjustable • advanced electrical and mechanical designs • high quality construction and manufacture.

Engineering Assistance **— on special applications, or where you have a problem, let our engineers provide the answers.**

O. C. White Lights distributed nationally by O. C. White Sales Co., Marblehead, Mass.

STOCKER & YALE

Lite-Mite Lights — O. C. White Lights

Want Details? ☐ **Catalog of standard lights** ☐ **Special requirement outlined in letter**

Just clip to your letterhead, sign and mail to: STOCKER & YALE, INC., 46 Green St., Marblehead, Mass.

ation in abnormal atmospheric conditions. Delivered assembled for wiring directly into circuit. Trans-Sil Corp, 55 Honeck St, Englewood, NJ.

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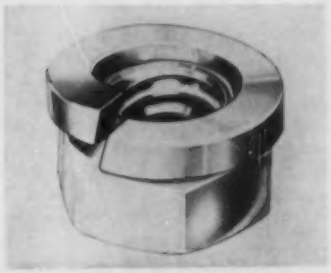

Nut with helical-spring washer are permanently held together, but are free to rotate when pressure is applied. Helical-spring washer is said to give high reactive range and spring tension, resulting in reduction in incidence of failure of bolted assemblies due to bolt stretch, thread creep and linear dimensional changes caused by rapid thermal expansion or contraction. Reliance Div, Eaton Mfg Co, Massillon, Ohio.

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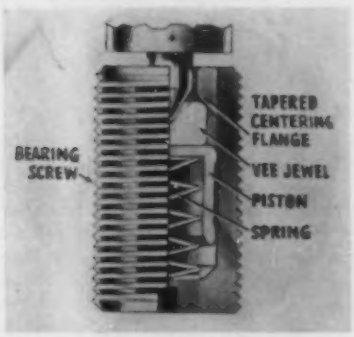

Neon panel indicator light is all-plastic light assembly, including bulb. Available with or without resistors. Tapered lens protrudes ¼-in. in front of panel for optimum light output. For use with high-brightness neon bulbs. Sloan Co, 7704 San Fernando Rd, Sun Valley, Calif.

Circle 320 on Reader Service Card

Jewelled bearings absorb shock . . . and protect equally against axial and radial shock. Radial and axial pressure are the same. Bearings are reported to make possible higher precision, as pivot diameter and pivot radius can be reduced, resulting in less friction. Protection is still warranted when pivot point radius is 15 to 20

continued on page 80

CIRCLE 79 ON READER SERVICE CARD

NOW! *Adjustable Diameter and Open* THOMSON

BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**

Precision Series "A" and Low Cost Series "B" BALL BUSHING

Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION • ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

THOMSON INDUSTRIES, Inc.
Dept. H, MANHASSET, NEW YORK

Also Manufacturers of NYLINED Bearings . . . Sleeve Bearings of DuPont Nylon, and 60 CASE . . . Hardened and Ground Steel Shafting

FIREBIRD PRODUCTS
for
PLASMA SPRAYING

New and exciting applications for NORTON FIREBIRD PRODUCTS are now possible. Commercial plasma spray equipment has extended the range of materials which can be utilized, so that now you can take advantage of the unusual and valuable properties of Borides, Carbides, and Nitrides in addition to Oxides as coatings.

These materials are now available from NORTON COMPANY in powder form, sized specifically for the various types of commercial spray equipment used today.

Investigate the possibilities of utilizing these high melting point products: their resistance to high temperature abrasion, erosion and corrosion and their electrical conductivity . . . both as coatings and shapes fabricated by Plasma Spraying.

Write NORTON COMPANY, Electro-Chemical Division, 225 New Bond Street, Worcester 6, Massachusetts.

Send for Bulletin,
"Norton Materials for Plasma Spray Coatings."

NORTON
ELECTRO-CHEMICALS

GIFTS OF THE FIREBIRD: compounds of silicon zirconium • boron • aluminum • magnesium titanium • chromium • including many borides carbides • nitrides • oxides

75 Years of...
Making better products...
to make your products better

microns and rotating mass is 250 to 300 milligrams. Design incorporates tapered bushing and spring-loaded piston that automatically positions jewel in dead center when outside pressure is relieved. **Foster Supplies Co, 6122 Milwaukee Ave, Chicago, 46.**

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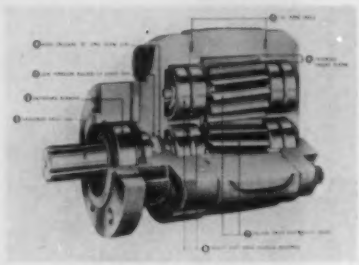

Fluid-power pump . . .

is reported to have constant volume output in five sizes ranging from 3 to 24 gpm at 1200 rpm. Rated for continuous-duty at pressures to 2000 psi and at speeds to 2400 rpm. Available in these gear widths: ½, ¾, 1, 1¼, 1½, 1¾ and 2 in. Can be delivered in round six-bolt, Type A SAE two-bolt and Type B SAE two- and four-bolt shaft-end covers. All internal parts are machined from one common reference: gear centerline. More than one pump, up to 4 in. total gear width, can be mounted in tandem. Volumetric and mechanical efficiencies rate over 90%. **Commercial Shearing & Stamping Co, Youngstown, Ohio.**

Circle 322 on Reader Service Card

Synthetic oil . . .

is light-viscosity diester oil featuring pour point of below 105 F. Lubricant meets requirements of low starting and running torques over temperature range of 100 to 250 F. Said to be compatible with ordinary lubricants. Available in pint, quart and gallon cans and 5- or 55-gal drums. **Lehigh Chemical Co, Chestertown, Md.**

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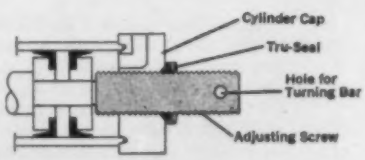

Cap-end stroke adjustment . . .

is available on all bore sizes of air and hydraulic Miller cylinders. Threaded adjusting screw with threaded fitting is device offered for adjustment of cylinder strokes. Adjusting screw is installed in cap end of power cylinder. Turning it clockwise causes it to enter cylinder bore where it acts as solid stop to limit stroke to exact length desired. Teflon-sealed straight-thread fitting seals adjusting screw against air or oil leakage from cylinder and keeps adjusting screw locked in position. **Miller Fluid Power Div, Flick-Reedy Corp, York and Thorndale Rds, Bensenville, Ill.**

Circle 324 on Reader Service Card

Xenon thyratrons . . .

capable of handling up to 1700 peak forward and inverse voltages, are rated at 130 commutation factor, low critical grid current and narrow, precisely held control range. Use of xenon-gas filling results in low tube drop (11-v average) with stable control in ambient temperatures of −67 to 167 F. Anode-current ratings are 6.4 A-dc continuous; 12.8 A-dc 3-sec overload; and 80 amp oscillograph peak. **Electrons Inc, 127 Sussex Ave, Newark 3, NJ.**

Circle 325 on Reader Service Card

12-hr stopwatch . . .

for panel-board and dash-board mounting incorporates heavy-duty components that qualify it for industrial, mining, over-the-road, aircraft, marine and test-bench service. Large, jumping hour-disk, full-circle center-shaft minute register, luminous markings on nonreflective black face and knurled turning bezel with large set mark facilitate visibility. For applications that require decimal data, alternate dial face with extra peripheral divisions in 1/100 min. is provided. Second auxiliary dial face reads in production units per hour (50 to 200) based upon time required to produce a single unit. Accuracy is said to be within ½ sec per hr over 18-hr wind. Mounting bolt center-line spacing is 1 11/16 in. Price is $52.50. **Heuer Timer Corp, 441 Lexington Ave, New York 17.**

Circle 326 on Reader Service Card

All-purpose rust inhibitor . . .

compound is said to protect new metals, fabricated parts, machinery and tools. Preparation is combination of active materials dispersed in oil carrier base. Ingredients are said to penetrate deeply through existing corrosion to bare metal

continued on page 82

Only VALCOR makes solenoid valves of TEFLON*

*DuPont Company registered trademark.

Now, from the company that pioneered the use of Nylon and PVC in solenoid valves for corrosive service, comes a solenoid valve with a **molded body and diaphragm of Teflon** that is **chemically inert and corrosion-resistant to virtually any corrosive medium you are now using.**

Valcor solenoid valves made of all Teflon are ideal for **critically** corrosive applications and where long life is essential. They will outlast and outperform steel. Available in a variety of sizes and pressure ratings. Stocked for immediate delivery. Write today for complete technical data.

VALCOR SOLENOID VALVES

VALCOR ENGINEERING CORP.

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CIRCLE 81 ON READER SERVICE CARD

General Electric RTV*
LIQUID SILICONE RUBBER

Cures at room temperature, useful from −70°F to +600°F

General Electric's expanding family of RTV silicone rubber compounds all cure at room temperature. They contain no solvents; resist temperature extremes, moisture, ozone, weathering and aircraft fuels. Available in a wide range of viscosities from 120 poises (lower than any other silicone rubber compound) to 12,000 poises. Important application areas include:

SEALING AND CAULKING

Aircraft manufacturers use RTV for pressure sealing of cabins and cockpits, fire walls, fuel tanks and hot air ducts. Protection for electronic packages is provided by caulking assemblies and sealing seams and lead holes with RTV.

ELECTRICAL INSULATION

Good electrical properties and outstanding heat resistance have led to RTV's use in coil impregnation and encapsulation of motors and transformers. Can be poured, sprayed, painted, or applied by dipping. Cure times can be varied from minutes to several days.

MOLDING AND TOOLING

Parts cast in flexible RTV molds reproduce with precision detail. Built-in parting agent assures easy release. RTV eliminates such common problems as excessive shrinkage and separate release agents.

*Room Temperature Vulcanizing

For more information and a free test sample, write (briefly describing your application) to General Electric Company, Silicone Products Department, Section 3, Waterford, N.Y.

GENERAL ELECTRIC

and to form solid air- and moisture-tight seal, preventing formation of new rust. Reported not to discolor metal. Ready to use without mixing. 1 gal is said to cover up to 400 sq ft. Compound is low in viscosity, nonsettling and nonfreezing. Price for 5-gal sampler pail is $8.95. **Brad Chemical Inc, 111 W Washington St, Chicago 2.**

Circle 327 on Reader Service Card

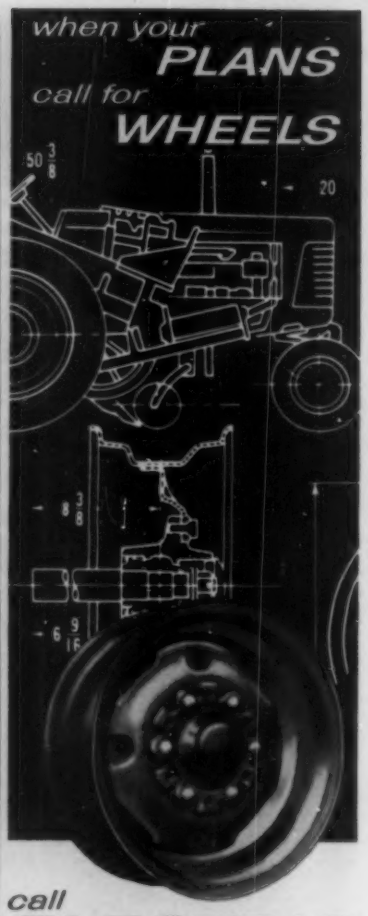
Motor is protected against overheating . . .

by use of positive-temperature-coefficient thermistors and semiconductors that are integral with motor. Motor protection is based on sensitivity of thermistors to heat buildup in motor winding alone, rather than being affected by line currents. Each thermistor is encapsulated in epoxy resin before installation in motor winding. It is not affected by temperature until it reaches predetermined critical temperature, designed for limitation of each insulation class and enclosure. At predetermined temperature, thermistor has 100 to 1 positive change in resistance vs temperature, providing snap-action response. Motor can be used for any ac application and protects against overheating due to single-phasing, locked rotor, too-frequent starting, repeated overloads, high ambient temperatures, abnormal voltage conditions, ventilation failures, switch welding and plugging or reversing duties. **Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.**

Circle 328 on Reader Service Card

Larger bin vibrator . . .

is in-line-action type of unit for installation on bin walls of about ⅜ in. thickness and 20-ton capacity. Double-impact vibrator provides impact at top and bottom of stroke. Hammer delivers 7200 impacts per min. at 60 cps. Without control box,



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ELECTRIC

for the quick answers and efficient service our over 100 years of agricultural and industrial wheel experience brings you.

Your every agricultural or industrial wheel requirement can be served by Electric Wheel. With able, experienced sales engineers who come equipped to help you with production schedules, prices and cost-cutting recommendations on the job, plan-to-production becomes fast and efficient. And it's backed by our ideal midwest location as well as the high quality and low cost capacities offered in the finest automated manufacturing and test facilities. Call or write today for the exact disc or spoke-type wheel (steel or rubber-tired), rim, hub, axle or component part you're looking for. ***What we sell is quality and service.***

ELECTRIC
WHEEL COMPANY

Write to Department 4-B
1120 N. 28th St., Quincy, Illinois
BAldwin 2-5320
Division of The Firestone Tire & Rubber Co.

CIRCLE 205 ON READER SERVICE CARD

unit is available for 115, 230, 460 or 575 v ac, directly off power line. Also furnished for 50 cps. **Eriez Mfg Co, Erie 6, Penna.**

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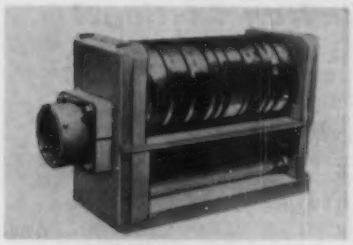
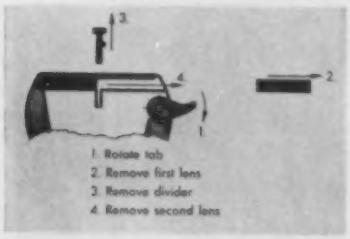


Electromechanical programer

specifically designed for on-off functions, is engineered with 30 circuits, carrying 2 amp resistive. Used to turn recorders, telemeters, valves, and motors on for definite period; then to turn them off. Delay before turning on, and on-time are preselected; they may be changed by changing program drums. Available with time range from 60 to 5000 sec and with accuracies of 1, 3 or 5%. Built to meet or exceed applicable military specifications. Said to withstand shock of 100 g, 10 millisec; vibration from 50 to 2000 cps at 0.1 in. double amplitude up to 20 g, and acceleration of 50 g along each major axis, 10 sec max duration. Operate in ambient temperatures of 65 to 200 F. **Sloan Co, 7704 San Fernando Rd, Sun Valley, Calif.** turer's 44 standard configurations. Re-

Circle 330 on Reader Service Card



Divided-word indicator light

provides two indications in space normally required for one. Divider is added, which forms two engraved legends and two indications, each half with its own independent lamp. Available for all this manufacturer's 44 standard configurations. Rebulbs from front. **Master Specialties Co, 956 E 108th St, Los Angeles 59.**

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Pocket-size digital calculator

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DESIGN LITERATURE

Writing in Industry

SIEGFRIED MANDEL, Polytechnic Press, Polytechnic Institute of Brooklyn, NYC. 6 x 8, 121 pp, $2.75.

These are selected papers from the proceedings of the conference on Writing and Publication in Industry, sponsored by the Polytechnic Institute of Brooklyn, 1959. The articles were developed independently by authors in science, engineering, personnel and public relations, science reporting and graphic art. It is remarkable that with such diverse backgrounds the authors have come to basically the same conclusion, namely that the responsibility for improving written communication rests with individuals who, by virtue of doing a specialized task, know most about it. The engineer cannot hope to find someone in his technical publicity or public relations department to do a commendable job of putting down his thoughts in writing. He must improve his knowledge of techniques in technical writing.

Papers in this text are: "The Challenge to Writers in Industry," by Siegfried Mandel, associate professor of English, Polytechnic Institue of Brooklyn; "The Relationship of Engineering and Technical Writing," by Robert T. Hamlett, director of training and personnel, Sperry Gyroscope Co; "Everyday Editorial Problems of an Engineer-Supervisor," by Ronald I. Ross, engineering section head for advanced studies, Sperry Gyroscope Co; "Techniques and Practices of Proposal Writing," by Donald L. Caldwell, proposal manager, Process Plants Div, Foster-Wheeler; "Writing for Publication: Why and How?" by George R. Wheatley, dept chief, Public Relations, Western Electric Co Inc; "Production and Design Problems in Engineering Publications," by Arthur Eckstein, Eckstein-Stone Inc; "Journalistic Aspects of Science Writing," by William L. Laurence, science editor of the New York Times.

Marketing

DUDDY and REVZAN. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6¼ x 9¼, 644 pp. $13.50.

This is a second edition of a standard text on marketing, intended for students specializing in this subject. It is reviewed here as a possible candidate for the elective reading of engineers because of marketing's influence on the process of developing products. In this book, marketing is defined as "the economic process by means of which goods and services are exchanged and their values determined in terms of money prices."

Propulsion Systems for Space Flight

WILLIAM R CORLISS. McGraw-Hill Book Co, 330 W 42nd St, New York 36. 6 x 9, 350 pp. $10.

The book makes an assessment of the entire field of thrust devices for use in outer-space exploration. The requirements of various space missions are compared with the abilities of the different propulsion systems, and power-generating and energy-conversion theories are analyzed over a wide power range. Such systems as nuclear rockets, ion drive, photon drive, and antigravity devices are compared in performance capabilities, technical feasibility, and present state of development.

Propulsion systems are considered from a practical viewpoint, emphasizing actual contributions, and assigning them roles in the over-all view of space technology. It integrates propulsion technology, sets up criteria for comparison, and evaluates the entire field. Previously this material has been accessible only in widely scattered technical papers and articles published by industry and government.

High-energy-rate Metal Forming

Interim Engineering Report No. 1. PB-161271, 110 pp. 9 x 12, $3.

Interim Engineering Report No. 2. PB-161272, 49 pp. 9 x 12, $1.50.

Interim Engineering Report No 3. PB-161273, 38 pp. 9 x 12, $1.25.

Office of Technical Services, Dept of Commerce, Washington 25, DC.

Contrary to popular claims, parts formed so far by explosive methods have been generally within the forming limitations of conventional techniques. The explosive processes, which form at speeds 100 times that of mechanical processes, increase ductil-

continued on page 87

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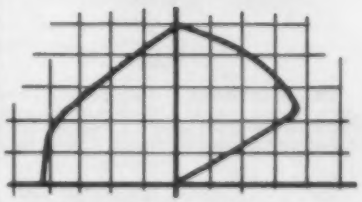

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Switch Types	N.O., N.C., or Double Throw — no neutral position.
Adjustments	J6K — internally located, uncalibrated adjustment wheel. J27KB — each switch has independent, uncalibrated adjustment screw.
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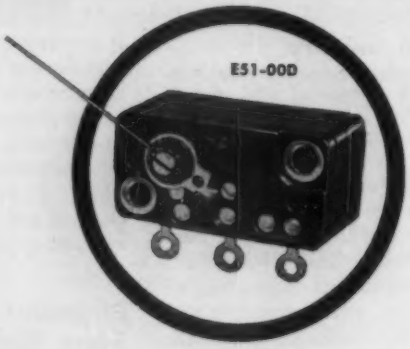

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This is a comprehensive report in three parts on the results of explosive forming, as found by 24 companies.

ABSTRACTS FROM THE LITERATURE

Plastic Colorants

Discusses coloring industry and how it services the plastics industry. Describes the advantages and limitations of available colors, colorants, and coloring techniques.

"How to Choose the Correct Colorant," Modern Plastics, April '60, 575 Madison Ave, New York 22.

Hydraulic Fluids

Discusses the main factors associated with the selection of a hydraulic fluid for optimum service.

"Application Aspects of Hydraulic Fluids," Mechanical World and Engineering Record, April '60, 31 King St West, Manchester 3, England.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

BRAZING-ALLOY PREFORMS – Brochure, 20 pp. Discusses design considerations and presents examples of metal joints that lend themselves to use of brazing alloys in preformed shapes. Lucas-Milhaupt Engineering Co, 5051 S Lake Dr, Cudahy, Wis.

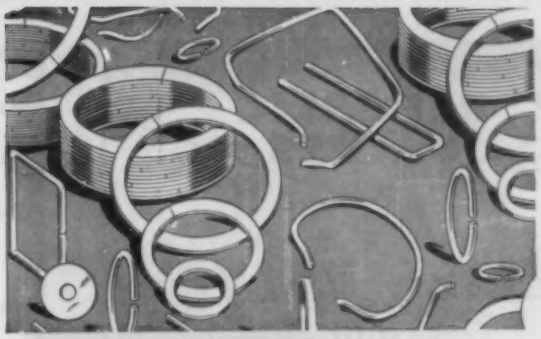
Circle 350 on Reader Service Card

CAST ALLOYS–Reference chart, 6 pp. Chart contains 55 of the more widely used cast alloys in the carbon, low alloy and stainless groups, as well as nickel and Monel. Covers composition, properties, specifications and design applications. Lebanon Steel Foundry, 143 Lehman St, Lebanon, Penna.

Circle 351 on Reader Service Card

ELECTRONIC COMPONENT PARTS –Catalog, 32 pp. Describes line of terminals, terminal boards and strips and

continued on page 89



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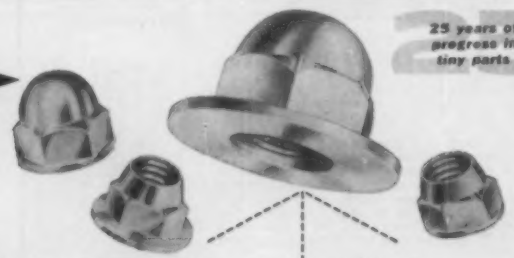

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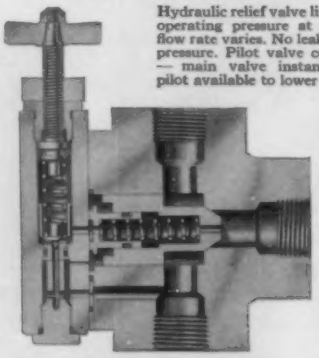

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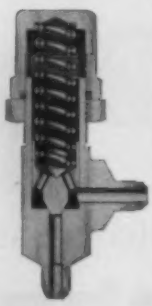

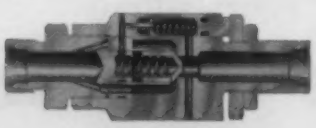

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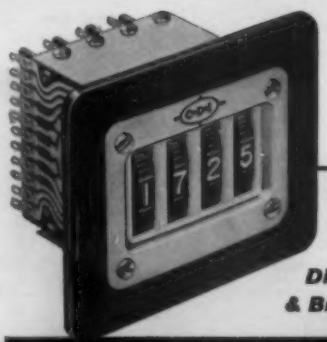

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other parts for military and commercial products. Also contains chart on typical values of laminates, including physical and electrical properties of those used in manufacturing terminal boards and special fabricated parts. National Tel-Tronics Corp, 52 St Casimir Ave, Yonkers, NY.

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POWER SUPPLIES—Handbook and catalog, 32 pp; price list, 6 pp. Describes voltage, current and performance characteristics of power supplies. Sorenson & Co Inc, Richards Ave, South Norwalk, Conn.

Circle 353 on Reader Service Card

FORCE-FEED LUBRICATORS—Catalog, 44 pp. Covers basic information on principles of force-feed lubrication, including data on viscosities of various lubricants. Illustrates many ways in which lubricators can be adapted to specific equipment. Chart compares lubricators with reference to pumping-unit characteristics, priming methods, drive types and locations and lubricants available. Manzel, 315 Babcock St, Buffalo 10, NY.

Circle 354 on Reader Service Card

INDUSTRIAL HOSE—Catalog, about 24 pp. Presents manufacturing facilities and complete line of industrial hose. Covers applications, cover, reinforcement, tube, lengths, packaging and recommended couplings. Swan Rubber Co, Bucyrus, Ohio.

Circle 355 on Reader Service Card

TRANSISTORS—Application guide, 16 pp. To facilitate selection, suitable transistor types for each major application are classified in terms of one or two important parameters. Charts indicate typical performance. Philco Corp, Lansdale Div, Lansdale, Penna.

Circle 356 on Reader Service Card

RTV LIQUID SILICONE RUBBER—Booklet CDS-226, 12 pp. Presents properties of room-temperature-vulcanizing liquid silicone rubber and illustrates its uses. Silicone Products Dept, General Electric Co, Waterford, NY.

Circle 357 on Reader Service Card

ROTARY DC SOLENOIDS—Bulletin 211, 6 pp. Describes five basic frame sizes of rotary dc solenoids, with specifications, dimensional drawings, typical torque characteristics, applications and design features. Outlines company capabilities. PSP Engineering Co, Dept RS, Maywood, Calif.

Circle 358 on Reader Service Card

HIGH-TEMPERATURE TAPES—Brochure, 6 pp. Presents information and properties of 10 high-temperature tapes

continued on page 90

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Circle 359 on Reader Service Card

LEVELING SCREWS—Bulletin 602, 6 pp. Dimensional information and typical applications of three styles of levelers are covered. Ohio Nut & Bolt Co, 33 1st Ave, Berea, Ohio.

Circle 360 on Reader Service Card

ALUMINUM-STAINLESS TRANSITION COUPLINGS—Brochure, 4 pp. Operational information, dimensions and performance characteristics of metallurgically bonded aluminum to stainless coupling for joint stainless steel pipe to aluminum pipe without flanges or gaskets. Project Fabrication Corp, College Point, NY.

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RADIO-INTERFERENCE FILTERS—Catalog, 4 pp. Includes case sizes, terminals, insertion loss, voltage drop, as well as current and voltage ratings. Schematics illustrate mounting styles and dimensions. All-Tronics, 45 Bond St, Westbury, NY.

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STEP-DOWN TRANSFORMERS—Bulletin 16-BO1, 2 pp. Covers specifications and dimensions on line of step-down and step-up transformers. Four examples of step-down-transformer applications are listed. Acme Electric Corp, Cuba, NY.

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POTENTIOMETER TRANSDUCERS—Bulletin, 4 pp. Contains transducer specifications as applied to pressure, motion, altitude, weight, flow, indicating, recording systems. H E Sostman & Co, 482 E Lincoln Ave, Cranford, NJ.

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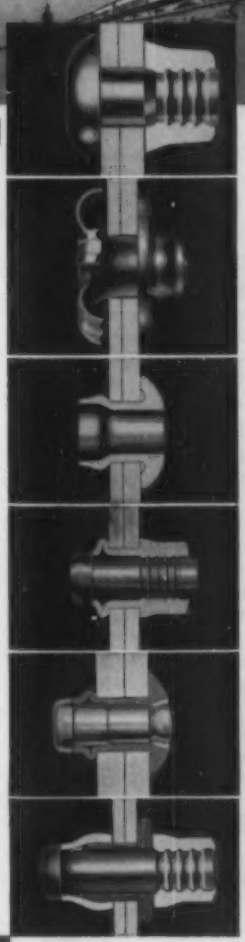

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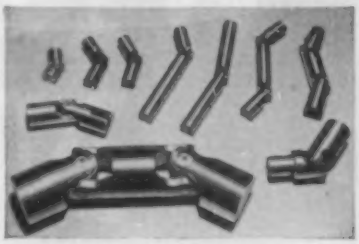

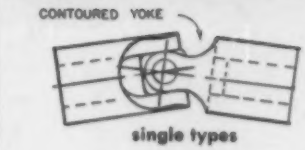

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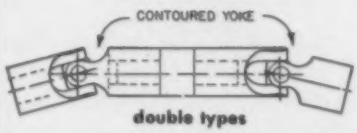

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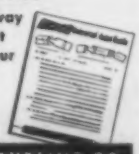

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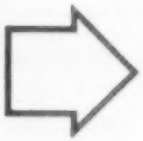

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359—High-temperature Tapes, 6 pp, Connecticut Hard Rubber Co.

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353—Power Supplies, 32 pp, Sorenson & Co Inc.

356—Transistors, 16 pp, Philco Corp.

358—Rotary Dc Solenoids, 6 pp, PSP Engineering Co.

362—Radio-interference Filters, 4 pp, All-Tronics

363—Step-down Transformers, 2 pp, Acme Electric Corp.

364—Potentiometer Transducers, 4 pp, H E Sostman & Co.

365—Subminiature, Free-filament Strain Gages, 4 pp, Baldwin-Lima-Hamilton Corp.

366—Potentiometers, 4 pp, Bourns Inc.

HYDRAULIC, PNEUMATIC EQUIPMENT

354—Force-feed Lubricators, 44 pp, Manzel

355—Industrial Hose, 24 pp, Swan Rubber Co.

ELECTRICAL, ELECTRONIC COMPONENTS

302—Elastic, Flexible Wire

303—Air-damping Dashpot

307—Miniature Mercury Switch

312—Controlled Voltage Device

314—Sealed Subminiature Switch

315—Linear Displacement Transducers

316—Adjustable Roller Arm

318—Silicon Power Rectifier

320—Neon Panel Indicator Light

325—Xemon Thyratrons

329—Larger Bin Vibrator

330—Electromechanical Programmer

331—Divided-word Indicator Light

HYDRAULIC, PNEUMATIC EQUIPMENT

300—Parallel-circuit, Directional Control Valves

301—Variable-capacity Rotary Pumps

304—Three Pumping Elements

305—Solenoid-operated Valve

308—Square-end Double Cylinders

309—Adjustable Unloading Valve

317—Midget Solenoid Valve

322—Fluid Power Pump

323—Synthetic Oil

324—Cap-end Stroke Adjustment

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Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
8	28	48	68	88	108	128	148	168	188	208	228	248	268	288	308	323	338	353	368	383
9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

REPRINTS

P35 P36 P37 P38 P39 P40 P41 P42 P43 P44
P45 P46 P47 P48 P49 P50 P51 P52 P53 P54

*MULTIPLE Key No.	PRODUCT ADS Specific Product

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Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
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16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
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REPRINTS

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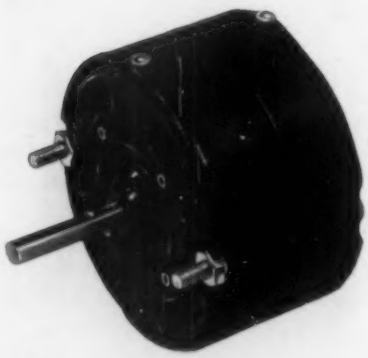

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